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Review of sentiment analysis in new product development: text, audio, visual, and multimodal data

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ABSTRACT
This research provides a literature review on the application of sentiment analysis (SA) in the new product development (NPD) process. The literature review employs a systematic literature review methodology. The steps include selecting a review topic, searching and selecting relevant articles, assessing and synthesising the literature, and organising the writing of the review. Sentiment analysis is a subdomain of natural language processing (NLP) that examines user opinions. The sentiment analysis methodology has been employed in the new product development process to replace traditional methods. Sentiment analysis can be conducted across various modalities, including text, audio, image, and multimodal formats. Text modality for sentiment analysis has been used to enhance the lifetime of products and services. Audio data and image modalities represent alternative modalities; however, they receive significantly less attention. The limitation is that these modalities are predominantly executed in controlled environments, utilising open-source or benchmark datasets, and some still employ text modality sentiment analysis methods or lexicons. Multimodal data, conversely, aims to augment the informational dimension of the text modality and is typically executed using deep learning models. This modality encompasses numerous combinations with the primary objective of enhancing the performance of sentiment analysis, hence reducing bias. The findings suggest that future research in this domain should focus on improving multimodal sentiment analysis to improve the new product development process.

KEY WORDS
sentiment analysis, new product development, multimodal, literature review

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Introduction

Product development is recognised as a vital activity that significantly contributes to a country's economic health, thereby supporting corporate survival and sustaining national economic prosperity (Craig & Hart, 1992). New Product Development (NPD) is a framework comprising a series of processes for developing new products. This terminology is used interchangeably with innovation and design, depending on the context, hence exemplifying the interdisciplinary essence of NPD. Until now, NPD has gained considerable interest and intensive research.

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A brief literature review in Section 1 demonstrates the rapid development of the NPD field in terms of paradigms, methodologies, and tools used in NPD. An important issue discussed in NPD is how to gather the Voice of Customers (VoC). Current research has shifted from capturing VoC through sentiment analysis (SA) from text-only input data (Renganathan & Upadhya, 2022) to capturing VoC through multimodal sentiment analysis (MSA) from diverse input data formats such as text, images, audio, and video (Chandrasekaran et al., 2021).

Based on the brief review, existing literature reviews did not specifically study how SA and MSA enhance NPD in gathering VoC. To fill the gap, a literature review on this topic is re-conducted, which is SA with different modalities, to answer the following research questions:

- What is the drawback of text modality to represent VoC?
- Can other modalities be used to represent VoC in NPD?
- Which modality potentially produces better results for NPD?

After the short literature review presented in Section 1, the remainder of this article is outlined as follows. The methodology of this literature review is presented in Section 2. Section 3 summarises the literature review results by SA type. Section 4 discusses the roles of various SA types in enhancing NPD. Finally, the conclusion of this review is presented in Section 5.

1. Literature review

NPD is a framework of processes for developing new products or services. Initially, a manufacture-centric paradigm underlies NPD formulation. Later, this paradigm shifts to a customer-active paradigm (Von Hippel, 1978) that enhances it by placing the customer at its core; however, this approach is limited to instances where the client is explicitly aware of the need for a new product. In this paradigm, it is important to define lead product users as users who articulate future product needs that eventually become mainstream (Von Hippel, 1986). In producing successful NPD, technological and commercial information is fundamental to the NPD process, providing the foundation for assessment and decision-making (Craig & Hart, 1992). Consequently, information is an element that necessitates further both empirical and theoretical exploration.

Subsequently, Wind and Mahajan (1997) examined contemporary challenges in NPD and asserted that the need for NPD redesign should extend beyond conventional qualitative methodologies, including focus groups, user surveys, and experiments. The conventional approach is deemed costly and offers just temporary engagement (Hoyer et al., 2010). The innovative method should facilitate the identification, development, and evaluation of a product or service. A possible method for achieving NPD redesign is to get data from unconventional sources of customer insight, as NPD must prioritise gathering relevant, trustworthy, valid, timely, and cost-effective information regarding customers and other stakeholders. The NPD process development must also include alignment with market requirements. Customer involvement in NPD is regarded as beneficial when executed during the initial and subsequent phases, using lead users to achieve significant economic appeal. Subsequently, Hoyer et al. (2010) presented a conceptual framework for customer co-creation. Customer co-creation can enhance efficiency and effectiveness, but it may also introduce additional costs and risks.

March-Chordà et al. (2002) identified that demand and market conditions in product innovation represent the most significant obstacles in the development process, potentially leading to the failure of product innovation. Concerning this issue, prior studies employed conventional techniques, including surveys, questionnaires, and interviews (Altuntaş, 2019; Rianmora & Werawatganon, 2021; Kulcsár, 2022). The limitations of methods that address evolving customer needs include the manual identification of these needs through instruments such as surveys, interviews, focus groups, ethnographic observation, and lead user theory. These approaches require significant time, financial investment, and resources, while only encompassing a limited customer segment, thereby diminishing reliability (Ireland & Liu, 2018; Quan et al., 2023).

Meanwhile, in the domain of artificial intelligence, there is a great interest in developing natural language processing (NLP). NLP emphasises computational linguistics applicable to language comprehension. Sentiment analysis (SA) is utilised in the development or enhancement of product lifecycles through NLP. SA output is expressed as semantic orientation (SO) from various modalities such as text, audio, visual, and multimodal (Chandrasekaran et al., 2021). The implementation of SA can be used in several contexts, including social media sentiment analysis, marketing and product review (Zad et al., 2021),

multimodal action recognition, market forecasting for trading systems, tourism sentiment analysis, health care, education and learning, human-computer interaction, recommendation systems, fraud detection, and sentiment regarding contemporary issues (Gandhi et al., 2023).

In their study, Schemmann et al. (2016) indicated that corporations are increasingly utilising crowdsourcing to gather innovative ideas from the general public in new product development (NPD). They demonstrated that crowdsourcing concepts from online platforms can enable organisations to harness collective intelligence to generate new ideas in new product development (NPD). The potential for idea generation from public opinion, coupled with SA capabilities, can effectively mitigate the drawbacks of the traditional NPD approach.

Based on preliminary research, the use of the text mining technique to produce sentiment orientation has gained a lot of attention compared to other modalities (Jin et al., 2016; Zhang et al., 2018; Lyu et al., 2019; Botchway et al., 2020; Visalli et al., 2020; Chiarello et al., 2020; Park, 2020; Renganathan & Upadhya, 2022; Lovera et al., 2021; Ng et al., 2021; Awajan et al., 2021; Obayed et al., 2021; Benlahbib & Nfaoui, 2021; Jiang et al., 2022; Verza et al., 2023). In the NPD process, text modality has been used to improve the performance and robustness in gathering voice of the customer (VoC) at the initial stages. The application lies in concept development to gather novel ideas for developing new products (Verza et al., 2023). However, since SA can be produced from other modalities, several literature studies have been conducted to investigate whether different modalities can be applied to improve the NPD process (Quan et al., 2023; Chandrasekaran et al., 2021; Zad et al., 2021; Gandhi et al., 2023; Drus & Khalid, 2019; Seng & Ang, 2019). Zad et al. (2021) have contributed to the available techniques for sentiment analysis and its application. Drus and Khalid (2019) contributed by depicting the use of sentiment analysis in social media and its application. Chandrasekaran et al. (2021) later expanded the review by investigating the current landscape of multimodal sentiment analysis (MSA), preprocessing, feature extraction, and fusion techniques, and by comparing SA techniques on several modalities. Seng and Ang (2019) also demonstrated SA for each modality and for multimodal combinations. Gandhi et al. (2023) later investigated the available dataset, the fusion method, and the future implications for MSA application. In their paper, Quan et al. (2023) proposed how data analytics techniques, using structured or unstructured data, can specifically improve product design activity by examining the traditional method.

2. Research methods

The literature study is conducted following the methodology proposed by Bodolica and Spraggon (2018). The initial step is to select a review topic. This step highlights identifying search keywords based on the author's preferences for this topic of interest. The range of topics starts with specific, focused subjects: "Sentiment Analysis", "Product Development", "Text", "Audio", "Visual", and "Multimodal". These keywords were chosen to acquire foundational theories, facilitate theory development, and implement them in SA to support the product development process. The subsequent step involves searching for and selecting appropriate articles. This step emphasises the systematic identification of topics with relevant information. The literature domain includes theoretical representations, review articles, and empirical research articles.

The search involved several group keywords with different modalities and open-access journals only. Text modality ("Sentiment Analysis", "Text", "Product Development") was used in 254 sources of literature; audio modality ("Audio", "Sentiment Analysis", "Product *") - in 554, and ("Sentiment Analysis" AND "Product" AND "Development" AND "Speech") - in 1410 sources of literature. Image modality ("Sentiment Analysis", "Visual", "Product *") was found in 89 sources of literature, ({Sentiment Analysis} AND {Visual} AND {Product *}) - in 1481, ("Sentiment Analysis", "Product", "Development", "Image") - in 1952, and ("Emotion", "Recognition", "Product", "Development", "Image") - in 4296 sources of literature. Multimodality ("Sentiment Analysis", "Multimodal", and "Product *") yielded 1356 sources of literature. The second attempt was made with a limit on open-access journals and a search within the abstract title, abstract, and keywords, with a broader keyword definition for image and multimodal modality. Image modality ("Sentiment Analysis", "Image") yielded 265 sources of literature. Multimodal modality ("Product Review", "Sentiment Analysis", "Multimodal") was used in 19 sources of literature, and ("Product *", "Multimodal Sentiment Analysis") yielded 32 sources of literature.

All keywords were obtained using the Scopus database. The search results were refined by selecting

relevant titles and a brief reading of abstracts. The pruning resulted in the text modality keywords yielding 21 references, audio modality keywords - 26 references, image modality keywords - 13 references, and multimodal keywords - seven references.

The next step involved analysing and synthesising the literature. This step underscores the necessity of scrutinising each reference and synthesising information depending on the article's compilation. The elimination process entails a concise examination of the abstract, methodology, conclusion, and its relevance to the application of SA and the implementation. For the context of the keywords "Sentiment Analysis", "Text", and "Product Development", the journals had to include SA and case studies, as they are exclusively focused on the product lifecycle; thus, any literature outside this scope was considered irrelevant. Consequently, the final compilation comprised 15 literature sources in text modality, three in audio modality, five in image modality, and eight in the multimodal category, with a total of 31 sources of literature.

The last step is organising review writing. This step emphasises the importance of structured review, facilitating readers' comprehension of the topic, and conducting a literature review in the same way. Based on the previously chosen publications, the author analyses and synthesises the topic from SA and product development. Each modality topic encompasses theory development and its application. This approach allows for journal mapping.

The study aims to illustrate the current landscape of the SA technique and identify a potential approach to leverage the product cycle, especially in the NPD context. Each keyword group undergoes a literature review and is mapped manually in draw.io. Synthesis is made to accommodate all keyword groups to form future research on how the NPD process can be enhanced using the best SA method.

3. Research results

NLP is recognised as a series of application domains within the computational linguistic community, employing various strategies for language comprehension (Bates, 1995). The NLP implementation in the product lifecycle encompasses SA, text summarisation, and subject modelling. SA is a computer method for recognising and classifying various ideas presented in textual format. SA is also commonly referred to as "opinion mining" and interprets user attitudes towards an object (Ding & Liu, 2007). Customer sentiment is a crucial factor for manufacturers to better understand their markets. Producers can use sentiment analysis to acquire client feedback on their product and subsequently enhance or modify it to address the issue.

In recent years, the use of SA has become increasingly important with the massive amount of data, known as Big Data, characterised by the 5Vs: volume, veracity, velocity, value, and variety (Quan et al., 2023). Other data types, such as audio, image, video, and multimodal modalities, have gained attention and may be used to improve SA. Several studies have proposed SA techniques for each of the modalities mentioned above.

The results of this review are classified into three subsections. The first subsection reviews textual data, the earliest and most common mode used for SA. The second subsection reviews results on single-mode, non-textual data to explore the SA potential using the non-textual mode. The third subsection reviews SA results using multimodal data types, in which more than one mode is used as input for the SA process.

3.1. Sentiment analysis on text data

Compared to other modalities, SA using text modality has attracted the most attention. Several studies have been conducted to improve product lifecycles. Research results on text data in the area of SA are presented in Fig. 1 and summarised in Table 1. In this subsection, the results are divided into four parts based on their application: tangible product, service, product and service, and others.

3.1.1. SA application for a product

Jin et al. (2016) proposed an approach for opinion data mining from customer reviews using Lexicon WordNet, the Kalman filter, and the Bayesian method on a smartphone product review. They analysed customer opinion data from the product designer's perspective. Zhang et al. (2018) proposed the Aspect Sentiment Collaborative Filtering (ASCF) method to capture different attitudes towards a product using SA on smartphone purchase records. ASCF uses a combination of SA and the Fuzzy Kano model to output a user's degree of desire and importance for a product feature. They also stated that different product categories may have distinctive characteristics. Also, this method is unsuitable for a small dataset on user purchasing behaviour. Special marketing

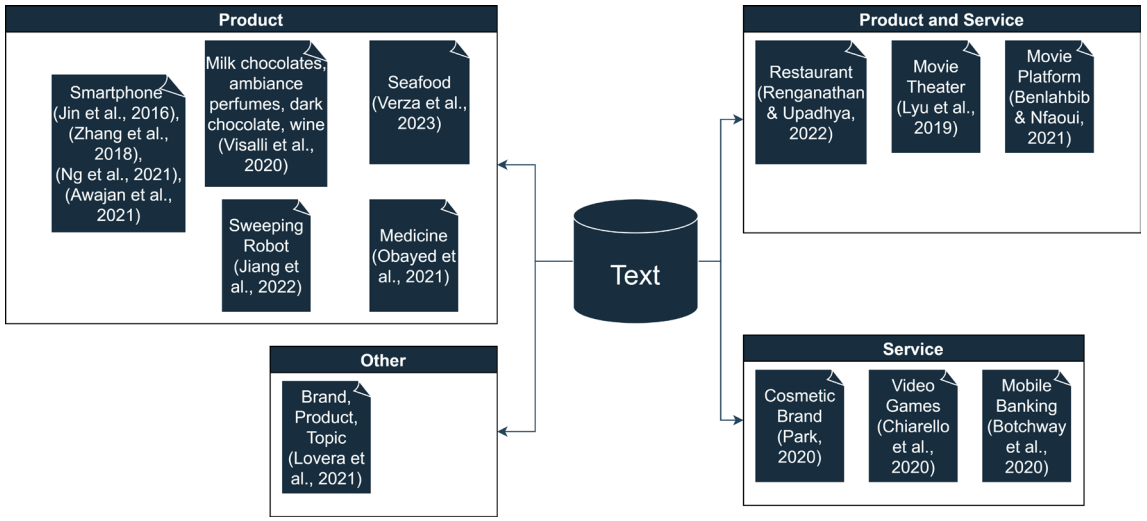

Fig. 1. Schematic diagram of sentiment analysis of text data

Tab. 1. Summary of research in the area of sentiment analysis of text data

Method	Language / Tools	Library / Add-On	Reference
Lexicon, Kalman Filter	Java	MIT Java WordNet	Jin et al., 2016
ItemCF, Fuzzy Kano Model	Python	NLTK	Zhang et al., 2018
Dynamic Topic Analysis (DTA), Autoregressive Heat-Sentiment (ARHS)	-	-	Lyu et al., 2019
Lexicon	Python	NLTK, VADER, SentiWordNet, AFINN	Botchway et al., 2020
Lexicon	R	Microsoft Text Analytics API	Visalli et al., 2020
Lexicon	-	-	Chiarello et al., 2020
Lexicon, TF-IDF	R, RapidMiner	Rvest	Park, 2020
Lexicon	R	TM, NLP, Syuzhet, Ggplot2	Renganathan & Upadhya, 2022
Knowledge Graph (KG), Long Short-Term Memory (LSTM), Bidirectional Long Short-Term Memory (BiLSTM), Local Interpretable Model-agnostic Explanations (LIME)	Python 3	TensorFlow	Lovera et al., 2021
Lexicon, K-Means	-	-	Ng et al., 2021
Lexicon, Simplified Neutrosophic Number Weighted Average Operator (SNNWA), Cosine Similarity, Score Function	Python, ScrapeStorm	NLTK	Awajan et al., 2021
Global Vectors for Word Representation (Glove), Bidirectional Long Short-Term Memory (BiLSTM)	-	-	Obayed et al., 2021
Embedding for Language Model (ELMo), Multinomial Naïve Bayes	ScrapeStorm	-	Benlahbib & Nfaoui, 2021
Particle Swarm Optimisation (PSO), Dynamic Evolving Neural-Fuzzy Inference (DENFIS)	Excel	Semantria	Jiang et al., 2022
Latent Dirichlet Allocation (LDA), Lexicon	Java, R	Machine Learning for Language Toolkit (MALLET), NRC Emotion Lexicon	Verza et al., 2023

activities affect sentiment, therefore creating bias for the Kano Model. Visalli et al. (2020) investigated the potential of the Microsoft API for sentiment prediction, measuring sentiment, liking, and the correlation from product sensory data. Their research concluded that sentiment analysis is not as reliable as an indirect measure of the liking score, especially when products differ slightly. They also stated that a score of 0.5 can express either a neutral stance or indetermination; that the ML model is not specifically designed for sensory data; and that, in a few cases, sentiment is simply dubious because it was created for long texts. Ng et al. (2021) proposed a framework for product evaluation using a lexicon and the K-Means algorithm for smartphone products from a Facebook fan page. Their research contributed a logical and practical solution for handling user-generated content (UGC). The drawbacks of their framework, including performance, are that it is highly affected by other product models for comparison, the involvement of expert judgement is required to compare products, and the use of a lexicon may be insufficient and imprecise, with varying opinions. Awajan et al. (2021) proposed a method for ranking products based on online customer reviews (OCR) using an integrated lexicon, the Simplified Neutrosophic Number Weighted Average Operator (SNNWA), cosine similarity, and a score function for smartphone reviews on Twitter. Their method combines the VADER lexicon with a neutrosophic number and later implements the cosine similarity to rank the product. Accuracy can be enhanced by integrating more neutral words from social media, and generalising neutrosophic logic can capture more uncertainty. Obayed et al. (2021) proposed a binary classification on the sentiment analysis of a pharmaceutical product using Global Vectors for Word Representation (GloVe) and Bidirectional Long Short-Term Memory (BiLSTM) on a review dataset. Jiang et al. (2022) proposed a model to depict the dynamics of customer preferences using a Particle Swarm Optimisation (PSO)-based Dynamic Evolving Neural-Fuzzy Inference System (DENFIS) trained on Amazon product reviews of a sweeping robot. Their research concerned customer preferences, which introduce variability and can be depicted as time-series data, given the ambiguity of emotions expressed by customers in online reviews. The relationship between product design attributes and customer preferences is crucial. However, this research has drawbacks: problems of neutrality and ambivalence are not considered in terms of sentiment analysis, and parameter tuning takes a long time. Verza et al. (2023) proposed a framework for NPD using a combination of Latent Dirichlet Allocation (LDA) topic modelling and a lexicon derived from online discussions for a seafood product concept. This research found that customer involvement in NPD could provide assistance and new market opportunities. Online discussion data can be used as an alternative to ethically formed data acquisition. Differentiating customers based on certain attributes can provide NPD that addresses a sample dimension. The drawbacks lie in limited customer involvement, which may result in only addressing personal preference; product ideas derived from consumers may not align with their purchasing behaviour.

3.1.2. SA application for service

Botchway et al. (2020) proposed an SA approach using a lexicon to better understand customer opinions towards mobile banking products. They suggested that a lexicon for text mining can help companies focus on vital cases, convey and exchange information fast, and enhance newly released products. The drawbacks of their research include using a single social media platform, the lack of other techniques such as topic modelling or the fuzzy rule-based method, and the use of only English tweets. Chiarello et al. (2020) developed a lexicon based on the advantages and drawbacks of products, associated with functional or physical underpinnings and using a newly released video game. They filtered data from Twitter in the context that the new product delivered more relevant, unambiguous information, identified reasoned and balanced customer opinions of their experience and could shed light on issues. Information from social media has drawbacks: it is difficult to untangle and understand in depth, and a risk may arise of underestimating endogenous extraction of opinions and beliefs.

3.1.3. SA application for both product and service

Lyu et al. (2019) proposed the Dynamic Topic Analysis (DTA) framework to handle electronic word of mouth (eWOM) data to extract heat and sentiment from movie daily ticket sales. They also proposed an autoregressive heat-sentiment (ARHS) model to enhance forecasted daily sales by integrating heat and sentiment into a predictive model; thus, it could be used to monitor customer feedback, issue warnings

during collaborative brand attacks, and better predict performance for sales. The drawback of this method is that it benefits only social media marketing for products and brands with massive social media data, and it integrates only eWOM and social media data. Renganathan and Upadhya (2022) proposed a sentiment analysis model on tourist restaurant reviews using a lexicon. This approach can help tourists find a suitable restaurant and compare restaurants within their categories. The drawback is that the use of a lexicon is unsuitable for comparison with machine learning (ML) or deep learning (DL) models; thus, it can be enhanced by using a hybrid method that comprises the lexicon-ML model to measure accuracy. Benlahbib and Nfaoui (2021) proposed a reputation system based on opinion mining and semantic analysis using Multinomial Naive Bayes. This approach results in a reputation value and visualisation to inform the user about the movie-related performance. Park (2020) proposed a framework to analyse relative customer satisfaction and its determinants in cosmetic brands using a sentiment analysis lexicon approach, statistics, and TF-IDF. This paper stated that using sentiment analysis can replace traditional methods, such as customer satisfaction surveys. The drawbacks, including dependency on a general lexicon, make analysis prone to bias, and sentient activation or deactivation is not considered, which potentially lowers the accuracy.

3.1.4. Other applications

Lovera et al. (2021) proposed an SA framework that uses knowledge graphs (KG) and DL techniques on Twitter short document data. The Local Interpretable Model-agnostic Explanations (LIME) model is used to uncover the so-called "black box", thus enhancing the truth in a predictive model. Using KG, the proposed framework captures tweet structural information with its meaning. This framework may produce an underfitting model since it uses only a limited amount of data. Therefore, as one of the disadvantages of this framework, it is sometimes unable to generalise the rules and distinguish sentiment.

3.2. Sentiment analysis of non-text data

Sentiment analysis has stretched beyond using text modality to produce sentiment orientation. Data in audio and image modalities are two modalities that interest many researchers and have ever-growing data availability that the Internet produces each day, especially through social media and e-commerce. Several pieces of literature have been studied to depict each modality used for product development. A schematic diagram of research results on SA into non-text data is presented in Fig. 2 and summarised in Table 2. In this subsection, the results are divided into two parts based on their modality: audio and image.

3.2.1. Audio modality

Sentiment analysis using audio modality has been applied for tangible products (Setchi & Asikhia, 2019; Ko et al., 2022). Setcho and Asikhia (2019) proposed a method for linking user sentiment with specific product design features by an ontology of image schemas and a lexicon in an offline session using alarm clock products. This approach can be chosen to investigate user interaction with products to help design intuitive use. This research stated that affectivity can influence user perception towards usability. Its drawback is that it excludes the use of interjection words to signify emotion. Ko et al. (2022)

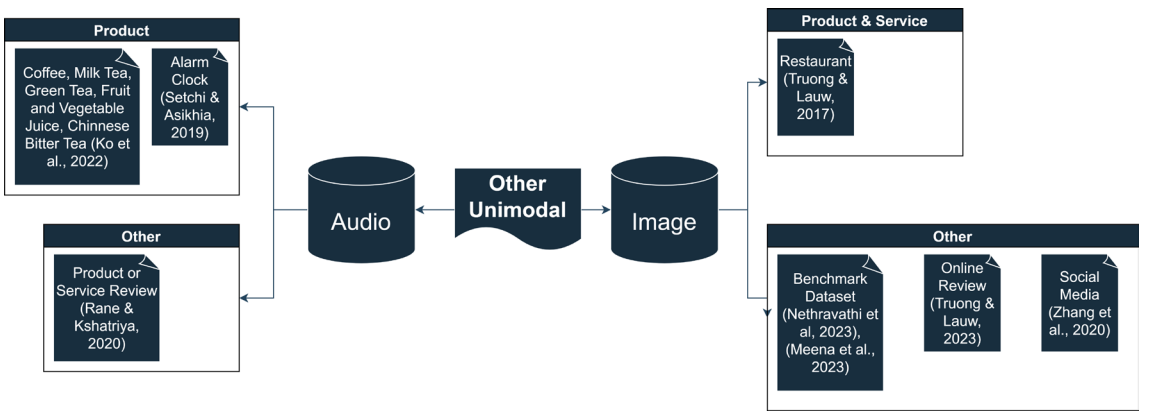

Fig. 2. Schematic diagram of sentiment analysis on non-text data

Tab. 2. Summary of research in the area of sentiment analysis on non-text data

Modality	Method	Language / Tools	Library / Add-On	Reference
Audio	API	Google Sheet, Liv.ai, Meaning Cloud	-	Rane & Kshatriya (2020)
Audio	Long Short-Term Memory (LSTM), MFCC, Support Vector Machine (SVM)	Audacity	-	Ko et al. (2022)
Audio	Lexicon, Ontology of Image Schema	C++	-	Setchi & Asikhia (2019)
Image	Convolutional Neural Network (CNN)	-	-	Truong & Lauw (2017)
Image	Convolutional Neural Network (CNN), Viola and Jones Algorithm	Python	TensorFlow	Nethravathi et al. (2022)
Image	Inception-V3 CNN	Python 3.9	TensorFlow 2.5	Meena et al. (2023)
Image	Vision Transformer (ViT)	-	-	Truong & Lauw (2023)
Image	Discriminant Correlation Analysis (DCA), Machine Learning Classifier, Sample Refinement (SR)	-	-	Zhang et al. (2020)

proposed a discriminative model to detect customer satisfaction via audio data using a Mel-Frequency Cepstral Coefficient (MFCC), LSTM, and a support vector machine (SVM) in an offline session interview about a food product. This research stated that acoustic analysis can be used to enhance customer relationship management (CRM). The drawback of this study is that it only uses the Mandarin language, and research has been done in a controlled environment, which makes it prone to bias in real-world applications.

Meanwhile, other applications of SA are found using audio modality. Rane and Kshatriya (2020) proposed an audio opinion mining and sentiment analysis framework for product or service reviews using phone calls. This framework utilises an API for speech recognition and sentiment analysis to generate reports. The drawback is that this research only uses a specific set of questions, therefore, outputting static feedback.

3.2.2. Image modality

SA using the image modality has also been investigated by Truong and Lauw (2017), who applied it to both products and services. They proposed an approach to infer sentiment from images using a convolutional neural network (CNN) on food product reviews. Image sentiment analysis of reviews may be affected by three factors: image factor, item factor, and user factor. Thus, items and user factors with facial recognition are proposed using CNNs to capture the interaction between image features and user expressions or items. The drawback is the bias from items, which can be positive in one context and negative in another.

Several other applications of SA using image modality have been offered (Nethravathi et al., 2022; Meena et al., 2023; Zhang et al., 2020; Truong & Lauw, 2023). Nethravathi et al. (2022) proposed using multiple CNNs to identify head posture and face emotion in customer engagement with an advertisement. First, CNN estimates head posture; then, it is used for face segmentation; and finally, it proceeds with face recognition and classification. This method is suitable for marketing, product likeability, client interest, and boosting sales. Meena et al. (2023) used an Inception-V3 transfer learning approach for the SA of image data. Inception-V3 transfer learning is a CNN-based method that can focus on the human body, which is a significant advantage over traditional CNNs. This research used benchmark datasets, such as FER2013, JAFFE, and Cohn-Kanade (CK+). It stated that image SA can be used in several contexts, including understanding customer perceptions of a product or service, building customer relations and loyalty, improving customer service, and utilising emotional marketing. The drawback of this research is the effort to manually tune parameters. Zhang et al. (2020) proposed the Multidimensional Extra Evidence Mining (ME2N) method for image SA, focusing on cross-modal sentimental semantics mining and the sample refinement (SR) process. The proposed model incorporates SR, Cross-Modal Sentimental Semantics Mining (CSS), and the ML classification algorithm. It was tested using social media and social networking websites. Based on this research, image SA can capture people's emotions, analyse mental states, and

benefit social or economic contexts. Truong and Lauw (2023) later proposed an image sentiment analysis by enhancing the Vision Transformer (ViT) model by incorporating concept orientation into the self-attention mechanism named SentiViT, which was tested on several online product reviews. This research stated that image sentiment classification could be used for measuring customer satisfaction and opinions on social media.

3.3. Sentiment analysis on multimodal data

This subsection reviews several research efforts that applied SA to multimodal data. Based on the modality used in the SA, these results can be categorised into (i) text and image modality, (ii) text, image, and behavioural features, and (iii) text and audio modality. A schematic diagram for the results of existing research in the area of SA on multimodal data is presented in Fig. 3 and summarised in Table 3.

3.3.1. Text and image modality

Ye et al. (2019) proposed the Deep Tucker Fusion (DTF) method for multimodal sentiment analysis (MSA) of the text and image modality and created a dataset for the modality, Product Reviews-150K (PR-150K), consisting of online shopping website data. The DTF method uses a CNN and a Gated Recurrent Unit (GRU) to predict sentiment.

Hou et al. proposed the VisdaNet framework for text and image MSA of restaurant online reviews (Hou et al., 2023a). This framework uses the Contrastive Language-Image Pre-Training (CLIP) model and the Bidirectional Gated Recurrent Unit (BiGRU) to perform sentiment classification based on visual distillation and attention mechanism. The CLIP model can distil knowledge by reducing either noise in a long text or missing information in a short text. CLIP-based visual attention fuses cross-modal features and information of a single text and multiple images.

Huang et al. (2019) proposed Deep Multimodal Attentive Fusion (DMAF) to perform image-text sentiment analysis with a semantic attention mechanism and mixed fusion using manual and machine-labelled data from social image websites. This model works by performing unimodal SA of each image and text modality first, then using an intermediate fusion-based multimodal attention model to depict internal correlation between modalities, and finally, performing a late fusion for final sentiment prediction. Later, Huang et al. (2020) proposed the Attention-Based Modality-Gated Network (AMGN) model to perform MSA using CNN and Modality-Gated LSTM using manual and machine-labelled data from social image websites. This approach analyses the correlation and discriminative information between modalities. A visual-textual attention model is used to learn a word-relative visual feature first, then, selection of a more emotional modality feature is performed using modality-gated LSTM; thus, a semantic self-attention model is employed to select a discriminative feature for sentiment prediction. However, this model is created based on an assumption that there is a fine-grained relationship between text-image pairs.

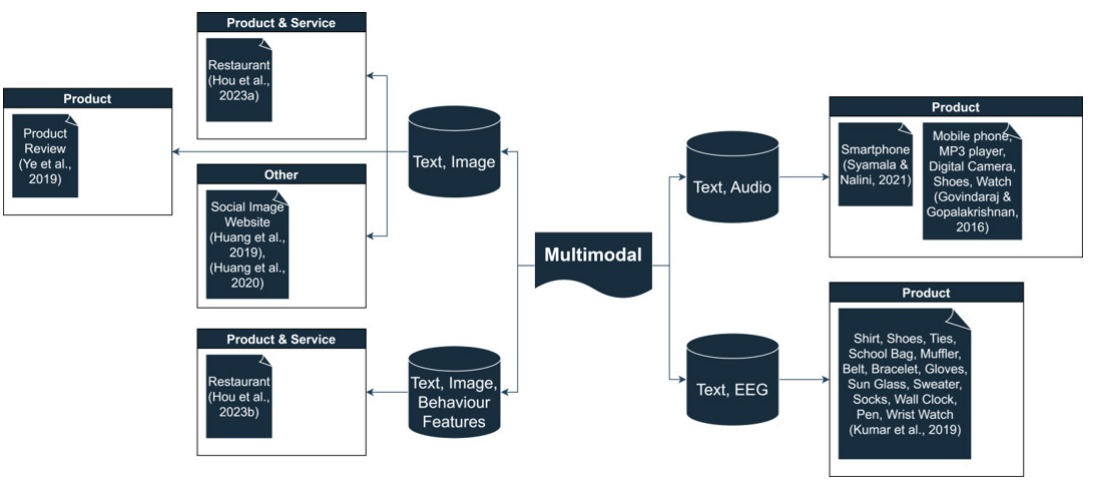

Fig. 3. Schematic diagram of sentiment analysis on multimodal data

Tab. 3. Summary of research on sentiment analysis of multimodal data

Modality	Method	Language / Tools	Library / Add-On	Reference
Text, Audio	Lexicon, OpenEAR + MFCC, Support Vector Machine (SVM)	-	-	Govindaraj & Gopalakrishnan (2016)
Text, Audio	Lexicon, Latent Dirichlet Allocation (LDA), Efficient Named Entity Recognition (E-NER), Convolutional Neural Network (CNN), Bidirectional Recurrent Neural Network (Bi-RNN), Normalised Weighted Aspect Extraction (NWAE)	Python	Gensim, Idamallet, WordNet	Syamala & Nalini (2021)
Text, EEG	Lexicon, Random Forest Regression, Artificial Bee Colony Algorithm (ABC), DWT Algorithm	-	-	Kumar et al. (2019)
Text, Image	Deep Tucker Fusion (DTF), Convolutional Neural Network (CNN), Gated Recurrent Unit (GRU)	Python	PyTorch	Ye et al. (2019)
Text, Image	Contrastive Language-Image Pre-Training (CLIP), Bidirectional Gated Recurrent Unit (BiGRU)	Python 3.6	TensorFlow 1.14.0	Hou et al. (2023a)
Text, Image	Convolutional Neural Network (CNN), Modality-Gated Long Short-Term Memory (LSTM)	-	TensorFlow	Huang et al. (2020)
Text, Image	Convolutional Neural Network (CNN), Long Short-Term Memory (LSTM)	-	TensorFlow	Huang et al. (2019)
Text, Image, and Behaviour Features	Contrastive Language-Image Pre-Training (CLIP), Bidirectional Gated Recurrent Unit (BiGRU)	Python 3.6	TensorFlow 1.14.0	Hou et al. (2023a)

3.3.2. Text, image, and behavioural features

Hou et al. (2023b) proposed the UsbVisdaNet model for MSA that emphasises reducing user bias in product reviews by adding psychological behaviour into VisdaNet for restaurant online reviews. This model is proposed because SA often struggles to consider the user attitude, whether it is constantly negative or positive. This approach improves sentiment classification, which is affected by user reviews using behaviour information.

3.3.3. Text and audio modality

Govindaraj and Gopalakrishnan (2016) proposed integration of sentiment and emotion analysis with text-speech modality for customer service product reviews to intensify sentiment. A lexicon was used for SA, then OpenEar and MFCC were performed for emotion recognition, and finally, a support vector machine (SVM) was used for sentiment classification. This method is proposed for automated customer behaviour analysis, customer redress systems, customised retail services, and business process quality improvement. Syamala and Nalini (2021) proposed a hybrid aspect-based sentiment analysis using fusion from the text-speech modality for reviews of a smartphone. This research proposes a speech-to-text model using a deep learning framework and a bi-gram language model to enhance the text transcript. Three text analysis models, including lexicon, topic modelling, and E-NER, are performed, thus using decision-level fusion to generate the final sentiment.

4. Discussion of the results

Verza et al. (2023) stated that new product success can be achieved by involving consumers in the first NPD phase, using a co-creation approach. Nowadays, customer review data can be easily obtained from social media, e-commerce, and blogs, revealing major customer requirements. This data can play a significant role in market-driven product design (Jin et al., 2016). Given the opportunity, many researchers use online review data to develop or enhance various products and services. The conventional way of preprocessing such data is to use sentiment analysis (SA) to provide a customer perspective on products or services.

Traditionally, SA and ER are obtained from the text modality. But in recent years, SA advancement resulted from Big Data, which can be characterised by 5Vs: volume, variety, velocity, veracity, and value

(Quan et al., 2023). Nowadays, SA can be obtained using several modalities, including text, images, speech, and multimodal. Thus, a literature review was performed to identify the current SA landscape in terms of several modalities for products or services. Each modality includes categories of product, service, product and service, and others. Products are used in literature sources that specifically use products as objects, and the same can be said for services. Some objects comprise both products and services, e.g., restaurants. Others do not belong to any category but state the usability of a product or service.

SA has concentrated on deriving Semantic Orientation (SO) from textual data. Sentiment analysis is commonly utilised in product or service evaluation data, including documents, websites, and online reviews. Numerous studies have examined the efficacy of online product reviews in text modality (Jin et al., 2016; Zhang et al., 2018; Lyu et al., 2019; Botchway et al., 2020; Visalli et al., 2020; Chiarello et al., 2020; Park, 2020; Renganathan & Upadhya, 2022; Lovera et al., 2021; Ng et al., 2021; Awajan et al., 2021; Obayed et al., 2021; Benlahbib & Nfaoui, 2021; Jiang et al., 2022; Verza et al., 2023). In terms of products, SA used the text modality to determine sentiment towards a product, product ranking, perceive trends, compare products, determine the degree of desire and importance of product features, product evaluation, analyse the dynamics of customer preferences, and develop ideas for NPD. In terms of a service, SA used the text modality to analyse customer satisfaction and advantages or drawbacks of products with functional or physical underpinnings. Several cases also addressed both product and service, which used SA for a recommendation system, reputation system, and extracting heat and product sentiment. However, several drawbacks can be identified, such as the use of a general lexicon, which can make the analysis prone to bias. Thus, it can be replaced by another approach considered more robust, i.e., topic modelling, the fuzzy rules-based method, or the hybrid lexicon-ML model (Botchway et al., 2020; Park, 2020; Renganathan & Upadhya, 2022). A lexicon also caused the output's unsuitability for comparing with an ML or DL algorithm and not giving sufficient and precise results with varying options (Renganathan & Upadhya, 2022; Ng et al., 2021). Special marketing activities will affect sentiment, thus blurring the real customer opinion (Zhang et al., 2018). Information from social media is difficult to untangle and understand in depth (Chiarello et al., 2020). Expert judgements are still necessary to produce a meaningful analysis (Ng et al., 2021). With limitations on customer involvement, it may yield results only addressing personal preference (Verza et al., 2023).

Significantly less frequent use of SA is found in the context of non-text modalities, including audio (Setchi & Asikhia, 2019; Ko et al., 2022; Rane & Kshatriya, 2020) and image (Truong & Lauw, 2017; Nethravathi et al., 2022; Meena et al., 2023; Zhang et al., 2020; Truong & Lauw, 2023) modalities for products or services. In terms of products, SA used the audio modality for opinion mining, detecting customer satisfaction, and linking product features with sentiment. For other cases, SA used the audio modality for opinion mining and sentiment analysis. However, several drawbacks can be identified, such as audio SA testing used in a controlled environment only (Setchi & Asikhia, 2019; Ko et al., 2022) and mostly treating audio SA as text SA, because audio data is transcribed into text (Setchi & Asikhia, 2019; Rane & Kshatriya, 2020). For the image modality, the use of SA is divided into products and services, and others. For products, SA captures the interaction of image features with user expression or items. For other cases, SA identifies emotions, classifies sentiments, and measures customer satisfaction and opinions. However, several drawbacks can be identified, such as a suggestion to monitor facial expression over time using object tracking and localisation (Nethravathi et al., 2022). The use of image modality in SA can be enhanced by integrating text to perform MSA (Truong & Lauw, 2017) and further refined by using a cross-modal analysis model, a GAN-based data augment model for sample refinement and integrating colour features for predicting the final sentiment (Zhang et al., 2020).

In recent years, SA has started using multimodality. Multimodality has many different combinations: first, text-image, which has been used for products, product and service, and others. In all those categories, this combination is used for sentiment classification. Second, text-image-behavioural features, which have been used for products. This combination is used for sentiment classification with consideration of user behaviour. Third, text-EEG, which has been used for products. This combination is used for product rating predictions. The last combination uses text and audio for the product category. It is used for sentiment intensification and aspect-based sentiment analysis. However, several drawbacks can be identified, such as performing research in a controlled environment (Kumar et al., 2019), in text and image

pairs, and assuming that both modalities have a fine-grained relation (Huang et al., 2020).

Conclusions

Natural language processing (NLP) emphasises computational linguistics applicable to language comprehension. One application of NLP in enhancing the product lifecycle is sentiment analysis (SA). SA has concentrated on deriving semantic orientation (SO) from textual data. Sentiment analysis is commonly used to evaluate product or service reviews, presented in documents, websites, and online assessments. This data can serve as a resource to enhance the product development cycle, particularly given that extensive studies have focused on text data. Social media data continues to grow, with large amounts generated by users. Big Data has 5V characteristics: volume, veracity, velocity, value, and variety. One social media characteristic is the availability of non-text data, such as images, audio, and video. With advances in SA, especially deep learning (DL) techniques, the non-text modalities can be used to produce sentiment orientation (SO).

Based on a literature review, SA used the text modality to improve product and service lifecycles. Most approaches use a lexicon, which has inherent limitations and is intended for general use; therefore, it could introduce ambiguity into the produced sentiment. Audio data and image data, respectively, are other possible SA modalities, but they gain substantially less attention compared to the text modality. These modalities are usually used with a DL and a pretrained model, potentially providing better SO than the text modality. The drawback is that both modalities are mostly used in controlled environments, with open-source or benchmark datasets, and some audio modalities still rely on the text modality SA (lexicon). Multimodal data, on the other hand, proposes to add dimensions of information from the text modality. It is commonly performed using the DL model. This modality has many combinations, as discussed above. The overall aim of the multimodal sentiment analysis (MSA) is to improve SA by combining modalities, thereby reducing bias in SO production.

Based on the insights from this paper, future research can focus on using MSA to improve the NPD process, especially in the ideation phase, by replacing traditional approaches such as surveys, questionnaires, and interviews.

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Impact of AI capability, digital strategy, and digital maturity on organisational performance

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ABSTRACT
In the face of the inevitable digitalisation of enterprises, limited research has investigated the impact of digital strategy, digital maturity, and AI capability on organisational performance. Drawing on the resource-based theory and recent work on AI in the organisational context, this research aims to uncover the configurations under which a firm's digital strategy, digital maturity, and AI capability would jointly lead to higher performance. This study uses a unique fuzzy-set qualitative comparative analysis methodology to analyse data collected from 56 SMEs to investigate three domains of AI capability, along with digital strategy and digital maturity. The results suggest that high organisational performance does not depend on a single condition but rather on complex synergistic interactions among the studied conditions. The results indicate that three equifinal configurations lead to high performance of SMEs. The study suggests that AI technical resources are mandatory for any viable solution. This study provides pioneering insights into the empirical contributions of AI capability, digital strategy and digital maturity and their relationships to organisational performance in SMEs, by using a configurational approach. The adopted theoretical perspective addresses the need for a holistic approach to uncover the mechanisms underlying digital strategy and digital maturity in relation to AI capabilities in SMEs, and their mutual impact on organisational performance. These results have practical implications for decision-makers and owners of SMEs, providing new insights into the combination of factors that drive high performance.

KEY WORDS
artificial intelligence capability, digital transformation, firm performance, fsQCA

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Introduction

The current surge of interest in artificial intelligence (AI) tools and applications in the business world is becoming a top technological priority. On the other hand, it entails major investments and challenges. Integrating AI tools into existing business models requires achieving a convergence of a set of resources to create the right capabilities (Drydakis, 2022; Wamba-Taguimdje et al., 2020). Understanding what resources need to be developed and deployed is essential for achieving performance gains through AI. In the literature, the AI capability construct, based

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on the resource-based theory (RBT) of the firm, is considered a higher-order construct conditioned by three types of resources, generally tangible, intangible, and human (Mikalef & Gupta, 2021; Akter et al., 2021). The literature on AI capabilities, although constantly evolving, remains rather scattered and requires further in-depth research, especially regarding the impact of AI capabilities on company performance. Nevertheless, it is worth noting the work of Abou-Foul et al. (2023), who developed a model supported by dynamic capabilities to assess the impact of AI capabilities on servitisation. In turn, in the work of Belhadi et al. (2021), organisational information processing theory was used to assess the impact of AI capabilities on supply chain performance in the context of resilience.

Previous literature reviews (e.g., Leidner & Preston, 2011; Parida et al., 2015) clearly indicated that developing innovative digital strategies through special digitalisation capabilities and experimenting with different technologies is an integral part of higher organisational performance. Companies that have a clearly defined digitalisation strategy, referring to making investment and personnel decisions to achieve technical progress and redesigning business processes to develop internal digitalisation capabilities, tend to achieve a competitive advantage (Matarazzo et al., 2021). In this context, as empirical studies indicate, the degree of digital maturity is important. In organisations with a high level of digital maturity, where business models are highly digitalised, companies have a clear and coherent digital strategy and often use digital technologies to achieve strategic goals and high performance (Kane et al., 2015). It has been proven that achieving a high level of digital maturity is a significant competence that allows organisations to respond quickly to opportunities and threats in the environment (Calli & Calli, 2021).

Following this trend, there is a lack of research focused on understanding the individual and combined factors related to the development of AI capabilities, digital maturity, and appropriate digital strategies that lead to improved firm performance (Fosso Wamba & Queiroz, 2023; Matarazzo et al., 2021). The following research gaps are often cited as important: the need for new empirical findings testing the theoretical approach to the perception of AI capabilities in relation to defining an adequate digital strategy and building digital maturity in a dynamic way, and examining the impact of dynamic shaping of these capabilities on firm performance (Steininger et al., 2022; Wilden et al., 2013). Furthermore, limited conceptual and empirical studies focus on the development of AI capabilities during digital transformation and on how organisational resources can be used more effectively and efficiently in these processes. To fill this important gap, this study explores possible explanations for important research questions:

RQ 1: What combinations of AI capabilities, digital strategy, and digital maturity could affect the firm's performance positively?

RQ 2: What are the core AI capabilities (technical, human, and infrastructure) for firm performance?

For this purpose, a configurational approach is used, which is better suited for analysing complex relationships, in particular fuzzy-set qualitative comparative analysis (fsQCA). This approach allows for gaining deeper insights into the dataset and the studied phenomena by discovering equifinal configurations (combinations of AI capabilities, digital strategy, and digital maturity) for high performance.

In terms of the contribution of this paper, first, it enhances understanding and knowledge by providing a model of the impact of AI capabilities, together with digital strategy and digital maturity, on company performance. Second, using fsQCA indicates different resource configurations and the existence of core and peripheral conditions in the discovered configurations. Furthermore, the study aims to promote activities regarding the contribution of technological innovations towards sustainable development. This research can support and provide some insights for the Sustainable Development Goals.

This paper is organised as follows. The next section reviews the literature on AI capability, digital strategy, and digital maturity as leading factors of digital transformation and their role in organisational performance. Then, the research methodology used to answer the research questions is described. The results of the analyses are presented in turn and discussed in relation to the findings of previous studies. The paper concludes with theoretical and practical implications and directions for future research.

1. Literature review

Adopting a resource-based theoretical perspective facilitates understanding how IT investments generate value and enable performance gains (Wade & Hulland, 2004). Knowing what AI resources firms need to develop is essential to achieving return on investment. Previous literature based on resource-based theory suggests that, in addition to the technol-

ogy itself, other human and complementary organisational resources are required to leverage the investment (Gupta & George, 2016; Mikalef et al., 2018). Empirical evidence from previous studies consistently demonstrates the power of RBT in explaining the relationship between organisational resources and firm performance. Moreover, this theoretical approach is particularly appropriate in turbulent and rapidly changing business environments because resource complementarity and the development of hard-to-imitate capabilities have long been associated with competitive success (Dutta et al., 2005). A fundamental premise of research conducted in the spirit of the resource-based approach, which also underpins this research, is the possibility of combining resources, which, in turn, facilitates the development of organisational capabilities that drive performance growth (Sirmon et al., 2011).

AI capability is defined as a firm's ability to select, organise, and utilise AI-specific resources (Mikalef & Gupta, 2021). Taking the resource-based view into account, organisations should deploy resources to build a set of AI capabilities, which in turn can help firms improve their performance. As indicated in the literature, AI capabilities include tangible resources (data, technology, investments, and time), intangible resources (coordination efficiency, firm capability, risk orientation, etc.), and human resources (employee business and technical skills). Previous studies have emphasised the importance of AI capabilities for creating firm performance (Wamba-Taguimdje et al., 2020; Mikalef & Gupta, 2021). Moreover, AI capabilities contribute to improving both business model innovation and firms' value proposition (Sjödin et al., 2021; Enholm et al., 2022). In this study, based on the insights of Wamba-Taguimdje et al. (2020), AI capability is presented as a high-order construct consisting of AI technical resources, AI human resources, and AI infrastructure. AI technical resources were assumed to include "AI-based algorithms that use various techniques such as machine learning, deep learning, and bots to support business operations" (Fosso Wamba et al., 2024). AI human resources, in turn, refer to the knowledge and ability of personnel to design and manage AI tools and applications. In contrast, AI infrastructure would refer to "connecting companies' technological resources (e.g., hardware, software, data centres, and databases) with their network resources (e.g., cloud solutions and data storage) to support AI tools and applications" (Fosso Wamba et al., 2024). As argued by Fosso Wamba et al. (2024), technical, human, and infrastructure resources can support the performance of firms in terms of AI capabilities. Moreover, recent reports on AI capabilities indicate that AI applications benefit stakeholders (Mikalef et al., 2022) and also significantly impact the performance of firms in supply chains (Belhadi et al., 2021).

Previous studies in the framework of observed digital transformation drew attention to the importance of information technology capabilities and resources, employee skills and abilities, and the presence of digital strategy (Eller et al., 2020). In the current business environment, integrating digital technologies and various IT systems with business strategies is an important element for achieving competitive advantage (Matalamäki & Joensuu-Salo, 2022). For this reason, it seems crucial to properly establish a strategic vision for the business and develop adequate processes for making strategic decisions and implementing them (Goodwin & Wright, 2001). Previous literature reviews emphasise that formulating innovative digital strategies through the development of special digital capabilities, as well as experimenting with various technologies, including AI, is an integral part of higher organisational performance (Leidner et al., 2011; Parida et al., 2015). As indicated by Montealegre (2002, p. 514), defining the right digital strategy is "a gradual process that is cumulative, extensive and highly dependent on the way in which difficult-to-imitate resources and activities are combined". Developing the right digital strategy requires a results-oriented business mindset that enables transforming existing business models and internal processes through advanced digital technologies. In turn, companies with a clear digital strategy for accelerating and developing digital capabilities stand out from their competitors (Matarazzo et al., 2021).

Moreover, empirical studies have shown that organisations with a clear and coherent digital strategy often use digital technologies to achieve strategic goals and are characterised by a high level of digital maturity and highly digitalised business models (Kane et al., 2015). Digital maturity, especially in relation to SMEs, includes such aspects as customer experience, operational processes and business models (Calli & Calli, 2021). Research from the perspective of SMEs indicates that digital maturity enables effective use of digital technologies to transform existing operations (Omrani et al., 2022). Digitally mature companies invest significantly more resources into developing staff skills to implement their strategies. In turn, achieving a high level of digital maturity

will be an important competence to respond quickly to environmental changes. However, it should be noted that most companies, especially SMEs, are just starting or are in the early stages of digital transformation and, therefore, have a low to medium level of digital maturity (Berghaus & Back, 2016).

In summary, although there is an increasing number of studies in the literature using the resource-based approach in IT and AI-related areas, the number of empirical studies examining the direct impact of AI capabilities in relation to digital maturity and digital strategy implementation on firm performance, especially in the context of SMEs, remains significantly low. It is also worth mentioning the recent study conducted on 209 digital manufacturing firms, which highlighted the positive association of dynamic digital capabilities with the financial and non-financial performance of firms (Wang et al., 2022). Moreover, with regard to digitalisation, previous studies have shown that having digital capabilities enables companies to achieve a wider range of strategic goals and build unique business models (Street et al., 2017). In turn, the dynamic relationship between digital capabilities and performance is strongly dependent on a firm's technological capabilities (Heredia et al., 2022).

Despite these recent reports, research conducted within the framework of digital capabilities, digital maturity or AI capabilities ignores the possibility of coexistence and interdependence between these factors. Recent empirical studies conducted on the interactions and construction of digital capability configurations in organisational contexts suggest such an existence. In this vein, Chu et al.'s (2019) pioneering study explores the relationship between IT capabilities, digital transformation, and innovation performance through configurational analysis, using data from 138 Chinese manufacturing enterprises.

To fill the existing research gap and provide new insights into AI capabilities, this research assumes that different configurations of AI capabilities, digital strategy, and digital maturity can be considered to explain high firm performance. According to the available literature, there is no such research addressing the configurational approach to the relationship between these factors and organisational performance, especially in the context of SMEs. As shown in Fig. 1, the research framework proposes that different configurations of AI capabilities, treated as a high-order construct, digital strategy and digital maturity, have a positive impact on organisational performance.

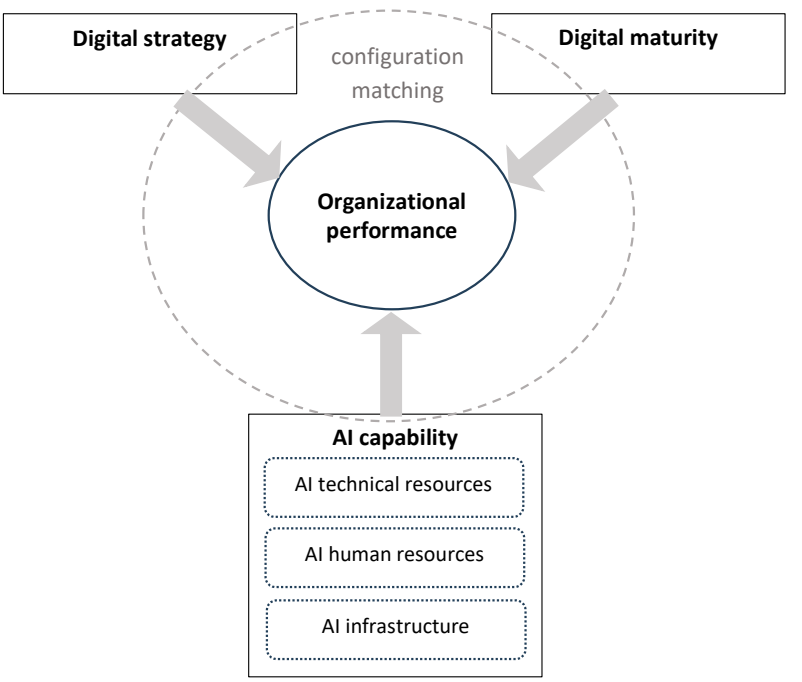

Fig. 1. Research framework of configurations producing organisational performance

2. Research methods

This study used the configurational approach to apply the fsQCA method based on set theory and fuzzy algebra, treating cases as sets of features expressed by their membership in the set (Ragin, 2000; Woodside, 2013). FsQCA enables insight into the different ways to combine features to create configurations associated with the analysed result. Importantly, this method, as indicated by the increasing number of examples of its application (Kumar et al. 2022; Kraus et al., 2018), has additional advantages over traditional methods. This means that it examines the relations between configurations of different causal conditions and the result. Moreover, it emphasises the equifinality of solutions, i.e., several paths (configurations) lead to the same result. FsQCA includes causal asymmetry, which indicates that configurations associated with the presence of the result are different from those associated with its absence (Ragin, 2008; Schneider & Wagemann, 2012). This study used version 3.0 of fsQCA for Windows (Ragin & Davey, 2016).

The research used a survey questionnaire, developed based on previous studies, characterised by high validity. In the first stage, the reliability of the research tool was checked on a sample of 39 respondents from ten SMEs. To examine AI capabilities, digital strategy, and digital maturity at the organisational level, this study collected data from Polish SMEs undergoing digital transformation and already having some achievements in this field. For this reason, the automotive industry was selected as one of the first to implement digital technologies and having more favourable hardware and software conditions than other industries (Schuh et al., 2017). The data collection process lasted three months at the beginning of 2024. Data were collected from 56 small and medium-sized enterprises in Poland, focusing on middle and senior management. A total of 113 questionnaires were initially collected. However, to ensure high quality and validity, invalid questionnaires (i.e., those that were empty and incompletely filled) were removed. Ultimately, 73 high-quality questionnaires were obtained. Descriptive statistics of the sample are presented in Table 1.

All measurement items used in this study were adopted from established scales. In this study, a seven-point Likert scale from "strongly disagree" (1) to "strongly agree" (7) was used to measure all constructs. AI capability, a high-order construct, is formed by AI technical resources, AI human resources, and AI infrastructure adapted from Mikalef and Gupta (2021) and Fosso Wamba et al. (2023). Digital strategy was measured with four items adapted from Eller et al. (2020) and Kane et al. (2015), while digital maturity was measured with four items adapted from Eller et al. (2020) and Li et al. (2022). In turn, organisational performance was operationalised based on the items proposed by Lee and Choi (2003). Table 2 presents all items included in the measures used in the study.

Subsequently, the fsQCA approach, integrating fuzzy sets and logical rules with Qualitative Comparative Analysis (QCA), was applied in the studies (Pappas et al., 2020; Ragin, 2000). Importantly, fsQCA allows for capturing conditions that are (1)

Tab. 1. Results of descriptive statistics of the sample

Content	Category	Proportion (%)
Gender	Male	85.7
	Female	14.3
Position in the company	Manager	29.3
	Senior Manager	43.7
	Executive (CEO, CMO, CFO, CIO)	27
Employed in the company	5 years	8.2
	6-10 years	18.9
	11-15 years	46.8
	More than 15 years	26.1
Company age	≤5	9.6
	6-14	38.4
	≥15	49.4
Number of employees in the company	<10	17.3
	<50	38.8
	<250	43.9

Tab. 2. Measurement items

Constructs	Items	Source
AI Capability	AI technical resources • In our organisation, we use machine learning platforms (providing algorithms, APIs, toolkits for building and training, data, and computing power to design, train and deploy models to applications, processes and other machines) to support business operations. • In our organisation, we use AI-optimised hardware (i.e., graphics processing units (GPUs) and devices specifically designed and engineered to efficiently perform AI-centric computing tasks) to support business operations. • In our organisation, we use deep learning platforms to support business operations. • In our organisation, we use robotic process automation to support business operations. • We integrate data from multiple internal sources into a data warehouse or storage to provide easy access. • We can efficiently prepare and cleanse AI data and evaluate data for errors.	Mikalef & Gupta, 2021; Fosso Wamba et al., 2023
	AI human resources • Our managers are able to understand business problems and direct AI initiatives to solve them. • Our managers are able to work with data scientists, other employees and customers to determine opportunities that AI might bring to our organisation. • Our managers are able to anticipate future business needs of functional managers, suppliers and customers and proactively design AI solutions to support these needs. • Our managers are capable of coordinating AI-related activities in ways that support the organisation, suppliers and customers. • We have strong leadership to support AI initiatives, and managers demonstrate ownership of and commitment to AI projects. • In our organisation, we take bold and wide-ranging actions to achieve the firm's objectives. • We typically adopt a bold, aggressive posture in order to maximise the probability of exploiting potential opportunities.	
	AI infrastructure • We have explored or adopted cloud-based services for processing data and performing AI and machine learning. • We have the necessary processing power to support AI applications (e.g., CPUs, GPUs). • We have invested in networking infrastructure (e.g., enterprise networks) that supports efficiency and scale of applications (scalability, high bandwidth, and low latency). • We have explored or adopted parallel computing approaches for AI data processing. • We have invested in advanced cloud services. • We have invested in scalable data storage infrastructures. • We have explored AI infrastructure to ensure that data is secured end-to-end with state-of-the-art technology.	
Digital strategy	Our company has a clearly defined digital strategy. • Our managers possess the awareness and skills necessary to implement our company's digital strategies. • We actively monitor digital trends that impact our industry. • We comprehend the potential effects of digital trends on our business model and strategies, and we take appropriate actions.	Eller et al., 2020; Kane et al., 2015
Digital maturity	• We have streamlined and digitised key business processes to enhance our profitability and competitiveness. • We organise our business processes and system infrastructure digitally to facilitate decision-making and value creation from data. • Our system infrastructure enables us to swiftly integrate new digital information technology solutions and services. • We encourage diversity of thought, knowledge sharing, and collaboration across all departments and teams, emphasising the adoption of new digital applications.	Eller et al., 2020; Li et al., 2022
Organisational performance	• Compared to our key competitors, our organisation is more successful. • Compared to our key competitors, our organisation has a greater market share. • Compared to our key competitors, our organisation is growing faster. • Compared to our key competitors, our organisation is more profitable. • Compared to our key competitors, our organisation is more innovative.	Lee &Choi, 2003

Tab. 3. Descriptive statistics and calibration values

Conditions/ Outcome	Descriptive statistics				Calibration criteria		
	Mean	Std. Dev.	Min	Max	Full in	Cross-over point	Full out
AI technical resources	3.8	1.0	1.0	5	6.80	5.33	2.78
AI human resources	3.9	1.1	1.2	4.8	6.41	5.25	2.34
AI infrastructure	4.1	1.0	1.4	5	6.60	5.50	2.50
Digital strategy	3.9	0.9	1.3	5	7.00	5.40	3.07
Digital maturity	3.8	0.9	1.4	4.9	6.80	5.50	2.47
Organisational performance	3.9	1.0	1.2	7	6.93	5.20	2.94

Tab. 4. Reliability test results

Conditions/Outcome	Items	Cronbach α
AI technical resources	6	0.976
AI human resources	7	0.876
AI infrastructure	7	0.952
Digital strategy	4	0.880
Digital maturity	4	0.90
Organisational performance	5	0.885

sufficient or necessary to explain the outcome and (2) insufficient in themselves, although they are necessary parts of the solutions that can explain the outcome (Pappas & Woodside, 2021; Ragin, 2008). The first step in the application of fsQCA is the calibration of the data on outcomes and conditions. The calibration process involves converting the raw data (measured at the ordinal, interval, or ratio level) into set membership scores, which are based on qualitative anchors (Kraus et al., 2018). Variables are converted into set memberships ranging from full non-membership (0) to full membership (1). The cross-over point (0.5) denotes the maximum ambiguity. To select the three thresholds and define the conditions (i.e., AI technical resources, AI human resources, AI infrastructure, digital strategy, and digital maturity) and the outcome (organisational performance), recommendations consistent with the work of Pappas, Woodside (2021) and Ragin (2008) were adopted and defined as follows: 0.95 (full membership), 0.5 (cross-over point), and 0.05 (full non-membership). The selected thresholds enable the examination of conditions that can explain very high organisational performance (i.e., 7 or 6 on the Likert scale). Most organisations in the sample have some experience with AI applications. The aim is to explain how companies that have already adopted or invested in AI and are performing at a satisfactory level (i.e., 4 or 5 on the Likert scale) can achieve very high performance by learning from those that have already reported such results. Table 3 presents descriptive statistics and calibration values for variables developed from the raw data obtained before calibration. It should be emphasised that the traditional linear approach was not used to analyse the associations between conditions and outcome. The findings presented next show how the configurational approach can reveal nonlinear, multiplicative, synergistic, and equifinal effects compared to the traditional linear approach (Fiss, 2007).

As shown in Table 4, Cronbach's α of the four conditions and outcome is greater than 0.8, indicating that the questionnaire of this study has considerable reliability.

3. Research results

Five conditions were considered in this study. Three AI capabilities (AI technical resources, AI human resources, and AI infrastructure), digital strategy, and digital maturity were antecedent conditions and organisational performance was used as the outcome (Table 5).

Before starting the actual configuration analysis, the "necessity" of each condition that impacts organi-

Tab. 5. Definitions of conditions and outcomes

Condition/Outcome		Code
Outcome	Organisational performance	OP
Antecedent condition	AI technical resources	AITR
Antecedent condition	AI human resources	AIHR
Antecedent condition	AI infrastructure	AIINF
Antecedent condition	Digital strategy	DS
Antecedent condition	Digital maturity	DM

Tab. 6. Analysis of the necessary conditions

Conditions	High organisational performance	
	Consistency	Coverage
AI technical resources (AITR)	0.624	0.591
~AI technical resources (~AITR)	0.463	0.501
AI human resources (AIHR)	0.665	0.628
~AI human resources (~AIHR)	0.469	0.473
AI infrastructure (AIINF)	0.509	0.510
~AI infrastructure (~AIINF)	0.603	0.475
Digital strategy (DS)	0.479	0.611
~Digital strategy (~DS)	0.452	0.443
Digital maturity (DM)	0.614	0.621
~Digital maturity (~DM)	0.636	0.548

Tab. 7. Configurations related to high organisational performance

Conditions	High organisational performance		
	C1	C2A	C2B
AI technical resources (AITR)	●	●	●
AI human resources (AIHR)	•		
AI infrastructure (AIINF)		●	●
Digital strategy (DS)	●	•	
Digital maturity (DM)	●		•
Raw coverage	0.488	0.398	0.347
Unique coverage	0.034	0.008	0.005
Consistency	0.935	0.951	0.966
Overall solution coverage			0.565
Overall solution consistency			0.918

Note. ● - core causal conditions (present); • - peripheral causal conditions (present); blank spaces indicate “do not care”.

sational performance should be tested. The test results are presented in Table 6. The consistency level is used to determine whether a condition is necessary. Following Ragin (2008), a condition can be considered necessary if its consistency exceeds 0.9. In this study, the consistency level for all conditions falls below 0.9, indicating that none of them can be considered necessary. In other words, the organisational performance of SMEs should consider the simultaneous and coordinated effects of AI capabilities, digital strategy, and digital maturity.

In the next step, a fuzzy set analysis was conducted to identify sufficient condition combinations that explain the high level of organisational performance. The first step is to create a truth table containing condition combinations that have strong membership in the outcome. Second, the truth table should be reduced to reasonable configurations by developing a rule. In this study, the truth table was further modified by setting the criteria of frequency N=2 and the lowest consistency score at 0.9 to avoid less reasonable combinations, as suggested by previous studies (Greckhamer et al., 2018; Kwiotkowska, 2024). Finally, the Quine-McCluskey algorithm, which is based on Boolean algebra, is used to logically simplify the truth table. Based on the obtained results, the conditions that appeared in both the intermediate solution and the parsimonious solution were identified as core conditions, while the conditions that appeared only in the intermediate solution were identified as peripheral conditions. The results of the fsQCA analysis in this study are presented in Table 7. When presenting the fsQCA results, the symbols traditionally used in the literature for this method were used. Therefore, in Table 6, the size of the circle distinguishes between the core condition and the peripheral condition. The large circle symbol represents the existence of the core causal conditions, the small circle symbol represents the existence of the peripheral causal conditions, and blank spaces indicate "do not care"; therefore, a condition that is irrelevant to achieving the analysed outcome.

Three configurations that can lead to high levels of performance have been identified: C1, C2a, and C2b, where C2a and C2b are equivalent second-order configurations, i.e., they share the same core conditions. The overall solution consistency is 0.918, which explains the significance level of the combined consistency of the causal recipes. This indicates that 92% of the cases that follow these three configurations exhibit high levels of organisational performance. Furthermore, the overall solution coverage is found to be 0.565, which means that the three configurations obtained in the study have a solid overall explanatory power that accounts for 57% of the observed high organisational performance in the cases included in the study.

The final solution regarding high organisational performance can be written in the following formula:

$$\text{AITR*AIHR*DS*DM + AITR*AIINF*DS + + AITR*AIINF*DM} \quad (1)$$

were:
the "*" sign represents the logical AND and "+" logical OR.

To ensure the reliability of the configuration analysis, a robustness test was conducted by changing the test conditions. For this purpose, the case frequency thresholds were adjusted from two to three, and the consistency threshold was changed from 0.9 to 0.8. The grouping of AI capabilities, digital strategy, and digital maturity in relation to high organisational performance was re-examined. The results showed no significant changes. Therefore, in line with the work of Greckhamer et al. (2018), Du Yunzhou et al. (2021) or Judge et al. (2020), it was found that if the parameter change does not cause significant changes in the number, composition, consistency, and coverage of the configurations, the results could be considered robust.

4. Discussion of the results

The results of this study contribute to the debate on the importance of AI capability for organisational performance. This research uses a configurational approach based on fsQCA, which provides in-depth insight into the set of conditions that facilitate company performance. The conclusions drawn from this study are that neither AI capability nor digital strategy nor digital maturity alone provides the necessary conditions for achieving high organisational performance. The results of this study show that with different combinations of antecedents, high levels of organisational performance can be achieved.

Based on the logical framework proposed by Ragin (2008), presenting the results of this research, it can be stated that three configurations leading to high organisational performance have been identified. Configuration C1 is AITR*AIHR*DS*DM. The configuration combines the presence of AI technical resources with the presence of digital strategy and digital maturity as core conditions and the presence of AI human resources as a peripheral condition. This

configuration accounts for 48.8% of the membership in the outcome and has a high level of consistency (0.935). This configuration suggests that all conditions except AI infrastructure play a role in determining high levels of organisational performance.

The next two configurations C2a: AITR*AIINF*DS and C2b: AITR*AIINF*DM are driven by two core conditions, i.e., AI technical resources and AI infrastructure. In configuration C2a, high organisational performance is additionally achieved thanks to the presence of digital strategy as a peripheral condition, and in the case of configuration C2b, the peripheral condition is digital maturity. In other words, regardless of AI human resources, SMEs can still achieve high organisational performance with highly developed AI technical resources and AI infrastructure as long as they have a highly developed either digital strategy or digital maturity. As shown by the conducted configuration analysis, it is possible to identify the interaction between the conditions (Fiss, 2011). By comparing the two configurations, C2a and C2b, having the same core conditions, it can be concluded that mutual substitution effects exist between digital strategy and digital maturity. In the case of SMEs with high AI technical and AI infrastructure, focusing on building the right digital strategy or achieving high digital maturity can lead to high organisational performance, as shown in Fig. 2.

The findings of this study offer important contributions to several streams of research (Table 8).

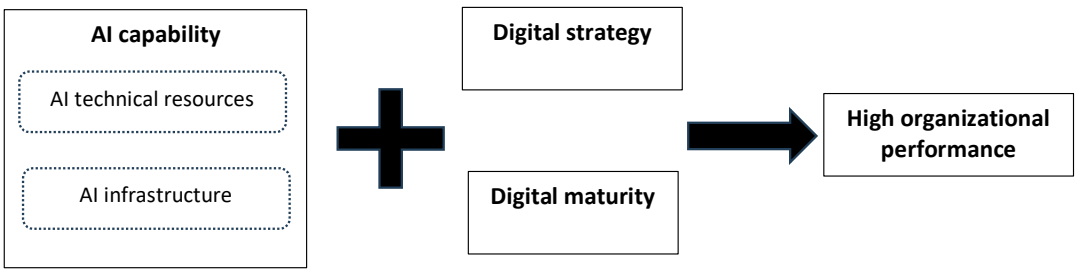

Fig. 2. Substitution between digital strategy and digital maturity

Tab. 8. Contributions of this research

Findings based on the fsQCA configuration approach	Theoretical contributions
The configuration model of AI capabilities, digital strategy, and digital maturity has been constructed.	Conducting new ideas for the research on AI capabilities in connection with digital strategy and digital maturity, constituting a certain continuation and extension of the research conducted in the literature, among others by Fosso Wamba et al. (2024), Mikalef and Gupta (2021).
AI capability, digital strategy, and digital maturity are not necessary conditions for high organisational performance alone.	Analysing the organisational performance from the configurational perspective of causal complex conditions, such as AI capability, digital strategy, and digital maturity, is helpful to deepen existing research and bring new insights into the relationships between these antecedent conditions.
AI technical resources are an important condition for SMEs to achieve high levels of organisational performance.	Confirming the strong impact of AI technical resources related to AI-based algorithms using, among others, machine learning on creating firm results and their organisational performance (Fosso Wamba et al., 2024).
Digital strategy and digital maturity with high AI capability can play a substitutive role in achieving high organisational performance.	Deepening insight into the substitutive role of the relationship between digital strategy and digital maturity and making up for the deficiency in this regard in the literature.
	Continuation of research suggested in the literature by, among others, Kane et al. (2015) on in-depth research of digital maturity and digital strategy, also from a configurational perspective.
	Showing the possibilities of using fsQCA to distinguish the relationship between various elements of the research model and to provide methodological guidance for further exploration of achieving high organisational performance in the era of digital transformation.

The conducted research demonstrates that AI capability, digital strategy, and digital maturity are not individually necessary conditions for achieving high organisational performance; however, their various configurations play a crucial role. In particular, the study emphasises the importance of AI-related technical resources in SMEs, which - through machine learning algorithms - can significantly enhance organisational effectiveness (Fosso Wamba et al., 2024). The findings also highlight the substitutive role of digital maturity and digital strategy when combined with high AI capabilities. The theoretical contribution lies in deepening the configurational perspective in digital transformation research and showcasing the potential of fsQCA methods to analyse complex relationships between digital resources and organisational performance (Mikalef & Gupta, 2021).

These results contribute to the broader scholarly debate on the strategic importance of digital resources and dynamic organisational capabilities (Bharadwaj et al., 2013; Teece, 2018). They underscore that digital transformation requires the integration of technology, strategy, and organisational competencies, rather than merely the implementation of isolated technological solutions (Vial, 2019; Yoo et al., 2010). In line with previous findings, an effective digital strategy should be grounded in a coherent business model that enables firms to respond flexibly to environmental changes and leverage the potential of digital innovation (Westerman et al., 2014).

Building on configuration theory (Furnari et al., 2021), this paper integrates five conditions - including AI capabilities, digital strategy, and digital maturity - to explore the complex causal mechanisms that ultimately affect the achievement of high organisational performance. The configuration analysis provided new insights into the identified combinations of variables, also suggesting directions for future research on the coupling of AI capabilities and antecedents of dynamic digital capabilities, particularly those related to digital strategy and digital maturity. Using fsQCA, it was observed that digital strategy and digital maturity can act as substitutes in configurations that lead to high organisational performance. This finding extends current knowledge of the relationship between these elements, particularly in the case of firms building strong AI capabilities.

With respect to high organisational performance, AI technical resources were found to be combined either with AI infrastructure or with AI human resources. Thus, the results suggest that AI technical resources are essential for building AI capabilities that support firm performance. Moreover, fsQCA revealed different configurations among high-performing companies. Interestingly, in none of the identified configurations did the AI capability construct encompass all three resources simultaneously. This indicates a further element of substitution, as AI technical resources - present in all three configurations - were combined either with AI human resources (Configuration C1) or with AI infrastructure (Configurations C2a and C2b). These findings address gaps in the existing literature and align with the results of Queiroz et al. (2023), who emphasised the importance of identifying key resource combinations under conditions of scarcity. This reflects the reality that not all resources contributing to AI capability are necessarily acquired at the same time. Resource-based theory further reinforces the importance of managing resource configurations as a source of developing key capabilities. Finally, the study contributes to advancing the multidimensional AI capability scale (Abou-Foul et al., 2023; Belhadi et al., 2021).

From a practical perspective, the results of this study provide directions for managers and practitioners. Practitioners should recognise that developing AI capabilities requires investing in key AI resources, i.e. technical, human, and infrastructure. Managers should also pay attention to building a digital strategy and achieving digital maturity, which, however, requires building high AI capabilities to achieve high performance. The results also reveal some implications and tips for decision makers, clearly indicating the importance of AI capabilities and their relationship with company performance in powering key elements of sustainable development. Decision-makers should pay attention to the importance of investment in AI technical and infrastructure resources, which in turn play a significant role in supporting the performance of the organisation. Secondly, as the results indicate, decision makers should consider the importance of supporting sustainable development using different configurations, which is especially important in relation to turbulence and changes in the environment.

This study has some limitations that may constitute a basis for future research. First, the data used in this study come from Polish SMEs from the automotive industry. Therefore, the research can not only be extended to other industries but also to other entities or regions. Next, in the collected data set, SME performance was subjectively measured based on the responses of senior managers. Such collected data,

although quite commonly used, may not fully reflect the actual results. In future studies, the use of objective performance measures may yield more accurate results. Moreover, the research was conducted in a specific time period, which does not allow for a precise examination of the dynamics of the analysed variables, e.g., AI capabilities. In the future, longitudinal studies may be considered.

Conclusions

A qualitative comparative analysis (fsQCA) of the configuration of AI capabilities, digital strategy, and digital maturity affecting organisational performance shows that no single condition is necessary for high performance. The results suggest that high organisational performance does not depend on a single condition but on the complex synergistic interactions between the conditions studied. The AI capability resources (AI infrastructure, AI human resources, and AI technical resources), placed within the research framework designed in this paper, can enable the discovery of different configurations leading to high organisational performance. Furthermore, the study suggests that AI technical resources are mandatory for any viable solution. The paper contributes to the RBV theory by suggesting that the configuration of AI capability, digital strategy and digital maturity are essential components contributing to a more sustainable society by improving enterprise performance based on the acquisition, use and management of the right resources.

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Convergence of marketing technologies and artificial intelligence: a bibliometric review (1987-2025)

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ABSTRACT

This article explores the intersection of artificial intelligence (AI) and marketing technologies (MarTech) by conducting a comprehensive bibliometric analysis. The aim is to identify dominant research themes, key contributors, and major gaps in the existing literature. MarTech is conceptualised as a system of digital tools that enables marketing transformation. Scopus and Web of Science were used to collect records. Following a preliminary comparison, the final analytical corpus of peer-reviewed scientific publications (n=492) was drawn solely from Scopus. The study is based on a dataset from 1987 to 2025. Using Biblioshiny, the analysis examined publication dynamics, citation patterns, co-authorship networks, and thematic clusters. The results indicate consistent growth in scholarly attention, with an annual publication increase of 7.39 % across the full period and 36.53 % between 2015 and 2025. Five primary thematic clusters were identified: (1) AI-Marketing Core and Innovation, this cluster acts as a motor theme, integrating innovation, AI applications, and marketing outcomes, and providing conceptual and methodological scaffolding for the field; (2) Technology Adoption, functioning as a basic theme, it connects sources of innovation with market outcomes; (3) Market Applications and Digital Commerce, this cluster reflects the operationalisation of value in commerce and digital marketing, exhibiting high centrality and moving towards motor-theme status; (4) Perception and Human-Centred Factors, representing a niche but strategically important human perspective; it moderates the relationship between adoption and outcomes. (5) Generative Artificial Intelligence (e.g., ChatGPT), this is the most emerging stream, acting as an accelerator for innovation, adoption, and applications, while simultaneously elevating the importance of quality, safety, and ethics. The United States, India, and China lead in publication volume, while the United Kingdom, France, and Australia demonstrate the highest citation impact. Despite the growing literature base, theoretical fragmentation persists, and limited studies address the ethical, social, and emotional implications of AI in marketing.

KEY WORDS

marketing, marketing technologies, MarTech, artificial intelligence

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Introduction

The dynamic development of marketing technologies, commonly referred to as MarTech, is attracting increasing attention from researchers and marketing practitioners. Today, MarTech solutions powered by artificial intelligence (AI) are becoming central to both academic discourse and practical innovation in marketing. AI-enabled marketing technologies represent one of the most strategically and methodologically complex areas of investigation within the broader domain of management and marketing science.

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These technologies are fundamentally transforming customer engagement, data-driven decision-making, and mass personalisation, thereby enhancing marketing effectiveness and organisational performance (Davenport et al., 2020; Kumar & Kotler, 2024; Wirth, 2018; Wirtz et al., 2018). As a result, marketing has emerged as one of the most technologically advanced functional areas of modern enterprises, undergoing a significant shift in required competencies.

This transformation necessitates not only advanced digital literacy among marketers but also a deep understanding of the technological landscape and rapidly evolving consumer behaviour. Key AI technologies accelerating this shift include machine learning, natural language processing (NLP), predictive analytics, and automated content generation. These tools increasingly underpin contemporary communication strategies by enabling real-time personalisation, automation of marketing processes, and data-driven decision-making (Huang & Rust, 2021, 2024; Kumar et al., 2024; Rust, 2020).

Despite their growing adoption, scholarly work on AI in marketing remains fragmented, spanning technological, ethical, consumer, and organisational domains (Chotisarn & Phuthong, 2025; Kietzmann et al., 2018; Lemon & Verhoef, 2016). An integrated perspective on the MarTech ecosystem - one that considers both theoretical foundations and practical applications - is, therefore, increasingly emphasised in the literature.

According to Chotisarn and Phuthong (2025), the study of marketing technologies is inherently interdisciplinary, drawing on frameworks such as service-dominant logic (Vargo & Lusch, 2004), dynamic capabilities theory (Teece, 2008; Teece et al., 1997), and technology acceptance models (de Andrés-Sánchez & Gené-Albesa, 2023). This orientation allows for a deeper understanding of complex phenomena related to digital transformation across various sectors, including retail, financial services, and tourism.

Given the rapid proliferation of publications in this field, a systematic review of the literature is warranted to identify dominant themes, structural trends, and knowledge gaps. The dynamic marketing environment presents both new avenues for academic inquiry and emerging directions for AI-driven tool development.

To assess the current state of research and the maturity of knowledge in this domain, the authors conducted a bibliometric analysis of peer-reviewed articles addressing the intersection of marketing technologies and AI. Using the Biblioshiny platform, the study examined publication trends, citation networks, co-authorship structures, and thematic clusters, culminating in a synthesised knowledge map that illustrates the evolving role of AI in marketing and outlines future research trajectories.

1. Research questions

In undertaking this bibliometric study, the authors adopted a descriptive bibliometric approach (Klincewicz, 2009), which enabled the identification of dominant research trends, leading scholars and institutions, and the assessment of the knowledge development trajectory in the domain of artificial intelligence (AI) applications in marketing technologies (MarTech). This method also facilitated the detection of research gaps and potential avenues for further investigation.

The analysis was based on bibliographic data retrieved from two leading scientific databases -Scopus and Web of Science - and included peer-reviewed publications from 1987 to 2025. The starting year corresponds to the earliest indexed works that jointly address both AI and MarTech. The dataset included metadata such as abstracts, keywords, author affiliations, and citation information, which were processed using the Biblioshiny platform. This enabled the visualisation of term co-occurrence networks, citation structures, and collaborative research patterns.

The study was guided by the following research questions:

- RQ1: What is the current state of research on the convergence of marketing technologies (MarTech) and artificial intelligence (AI)?
- RQ2: How has the literature in this area evolved over the past four decades?
- RQ3: Which research institutions and authors are the most active in publishing within the AI-MarTech domain?
- RQ4: What gaps and limitations exist in the current body of literature, and what opportunities do they offer for future research on AI-enabled marketing technologies?

The adopted approach provided a cross-sectional view of the current scholarly landscape, highlighting research intensity zones and revealing thematically significant areas that merit deeper theoretical and practical exploration.

2. Research methods

2.1. Search strategy and data collection

The research questions outlined above informed the scope of keywords and search queries used to curate a focused set of scientific publications. Searches were performed using English-language terms such as "AI", "artificial intelligence", and "marketing technology" across the Scopus and Web of Science databases.

The search and data preparation process followed a structured four-step procedure:

- Identification of relevant bibliographic databases (Scopus and Web of Science);
- Selection of bibliometric analysis tools (Bibliometrix R. Package, R language, Biblioshiny App: Bibliometrix for non-coders: Most relevant authors, Authors' production over time, Co-Citation Network, Collaboration Network, Clustering algorithm, Most Frequent Words, Co-occurrence network, Thematic map, Thematic evolution, etc.),
- Development and testing of inclusion keywords and phrases;
- Application of inclusion and exclusion criteria based on content relevance and academic quality (Klincewicz et al., 2012; Żemigała, 2018).

This process established a consistent and replicable framework for assembling a high-quality research dataset suitable for bibliometric analysis.

The bibliometric method was selected consciously, guided by the nature of the investigated phenomenon and its current stage of development within the academic discourse. The convergence of artificial intelligence (AI) and marketing technologies (MarTech) constitutes a relatively recent, dynamic, and multifaceted research area that necessitates, as an initial step, the systematisation of existing scholarly contributions, the identification of dominant research streams, and the detection of potential thematic gaps. With these factors in mind, the authors adopted a sequential research design in which bibliometric analysis serves as a methodologically sound foundation for subsequent in-depth investigations.

Unlike a traditional narrative literature review, the bibliometric approach enabled a more objective, systematic, and quantifiable analysis of the global body of literature. The literature review was deliberately planned as the second stage of the research process to mitigate risks of subjectivity, thematic narrowing, and selective inclusion of sources. Beginning with a bibliometric analysis allowed the authors to avoid the "bias of selection" commonly associated with narrative reviews (Snyder, 2019).

Using the R environment and the Bibliometrix package, the authors conducted a series of analyses, including citation analysis, co-word analysis, co-authorship network mapping, source analysis, and crucially, thematic clustering. This approach allowed for a comprehensive mapping of the knowledge structure and the temporal evolution of the field.

It is also important to emphasise that the time frame of the study (1987-2025) encompasses two rapidly evolving domains, artificial intelligence and marketing technologies. Both fields undergo constant technological, cognitive, and practical transformations, making manual tracking via literature review alone highly challenging, if not unfeasible. In this context, bibliometric tools enabled the authors to process and analyse hundreds of records simultaneously, providing the necessary scalability and precision required to explore such a dynamic research landscape (Donthu et al., 2021).

An essential factor justifying the use of bibliometrics in this study was its capacity to identify so-called thematic clusters, groups of publications linked by shared topics or methodological approaches that often signal the emergence of future research directions. The co-word analysis facilitated the identification of frequently co-occurring concepts, technologies, and research streams. This, in turn, allowed the authors to recognise not only leading topics but also research gaps that had been previously overlooked or marginally addressed (Aria & Cuccurullo, 2017; Massimo & Cuccurullo, 2017). The application of bibliometric analysis in research related to marketing and technology is well-established and has yielded significant insights, particularly in the fields of digital marketing, mobile technologies, and artificial intelligence in managerial contexts (De Luca et al., 2021; Thakur & Kushwaha, 2024).

In light of the early, dynamic, and multifaceted nature of the AI-MarTech convergence, bibliometrics constituted a critical and foundational method at this

Tab. 1. Search strategies for academic databases

Scientific search engine	Search phrases
Scopus	*TITLE-ABS-KEY (AI OR artificial intelligence) AND (marketing) AND (technology)*
Web of Science	*TS=(AI OR artificial intelligence) AND (marketing) AND (technology)*

stage of the research: it enabled an objective, scalable mapping of the literature corpus, reduced the risk of selection biases typical of narrative reviews, and captured the knowledge structure and its temporal evolution. The use of the Bibliometrix package (R) further allowed the identification of thematic clusters, dominant research streams, and research gaps that had hitherto been marginalised in the literature.

2.2. Inclusion and exclusion criteria

To ensure thematic relevance and analytical rigour, the following criteria were applied:

Inclusion criteria:

- Peer-reviewed research articles and literature reviews;
- Publications written in English;
- Articles published in any year, without time restriction;
- Articles indexed in the fields of business, management, or closely related areas;
- Explicit focus on artificial intelligence in the context of marketing technologies.

Exclusion criteria:

- Publications not directly related to AI or MarTech (off-topic);
- Non-English articles;
- Duplicates;
- Other publication types (e.g., book chapters, books, conceptual essays, workshop materials, student theses, editorials, or posters).

This methodologically grounded selection process ensured both the relevance and quality of the final dataset. By focusing on validated scholarly outputs from two high-impact databases, the authors assembled a coherent and representative corpus. This collection served as a reliable foundation for analysing trends, mapping the evolution of AI-MarTech research, and identifying emerging conceptual clusters.

3. Research results

3.1. Dataset and indicators

To ensure methodological consistency, Scopus and Web of Science databases were queried using standardised keyword sets and filtering protocols. The search was limited to peer-reviewed articles published in English and indexed in the fields of business, management, and social sciences. To identify the thematically most appropriate set of scholarly publications, the authors implemented a five-stage protocol for preparing and selecting the database for the bibliometric analysis. The protocol comprised the following stages (Fig. 1):

- Specification of article selection criteria;
- Curation of article datasets from Web of Science and Scopus;
- Preliminary analysis of both datasets based on author-supplied keywords;
- Decision regarding the selection of the database to be subjected to the main analysis;
- Main bibliometric analysis.

Preliminary analysis based on author-supplied keywords revealed that, although the Web of Science dataset was substantially larger (1,512 publications), only 3 % of its records contained the keyword "marketing", whereas the share in Scopus exceeded 7 % in 449 publications. This pronounced disparity informed the decision to designate Scopus as the primary dataset for the subsequent bibliometric analysis. Following the preliminary comparison, the final corpus of 492 records was drawn from Scopus only (post-filtering), which we treat as the primary dataset for all subsequent analyses.

The final dataset consisted of 492 scientific publications published between 1987 and 2025, drawn from 278 unique sources (journals). The analysis confirmed a clear upward trend in scholarly interest: the average annual growth rate of publications during the study period was 7.39 %, which reflects the dynamic expansion of this interdisciplinary field (Small, 1999).

The dataset included contributions from 1,431 unique authors, of whom only 69 authored single-author papers, accounting for 4.82 % of the total. The average number of co-authors per article was 3.17, indicating a high degree of collaboration and the dominance of team-based knowledge production, particularly in technologically intensive domains, such as AI and marketing. Moreover, the share of international co-authorship reached 27.24 %, underscoring the global scope of the discourse (Glänzel & Schubert, 2004; Moed et al., 2004).

The average citation rate across the sample was 34.71 citations per document, signalling a high level of academic impact. The average document age was 3.35 years, which confirms the field's orientation towards recent developments, typical for disciplines shaped by rapid technological innovation (Bornmann & Daniel, 2008).

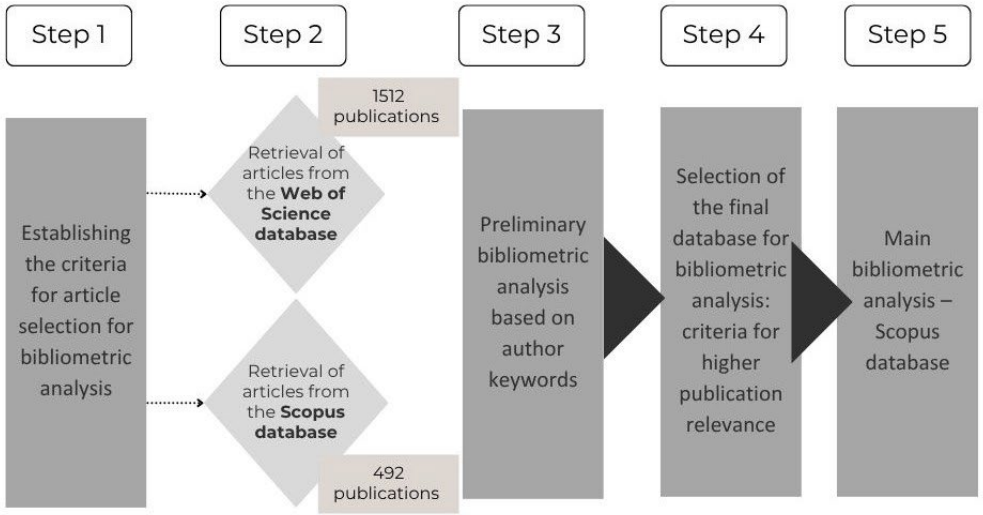

Fig. 1. Stages of preparation and selection of the database for bibliometric analysis

Tab. 2. Author keyword analysis in the Web of Science and Scopus databases: a preliminary assessment underpinning the selection of the database for the final bibliometric analysis

Web of Science database	
Author keywords	Number of publications
artificial intelligence	456
technology	69
ai	65
artificial intelligence (ai)	56
marketing	48
machine learning	45
innovation	42
artificial	36
intelligence	32
generative ai	31
digital marketing	25
digitalization	25
anthropomorphism	24
chatgpt	23
trust	22
business	20
chatbot	20
customer experience	20
technology adoption	20
blockchain	18
performance	18
big data	17
service	17
chatbots	16
digital	16

Scopus database	
Author keywords	Number of publications
artificial intelligence	233
marketing	56
digital marketing	33
machine learning	30
ai	29
technology	26
artificial intelligence (ai)	21
big data	19
chatgpt	15
internet of things	14
innovation	12
social media	12
technology adoption	12
tourism	12
generative ai	11
generative artificial intelligence	11
covid-19	10
customer experience	10
digital transformation	10
adoption	9
chatbots	9
chatbot	8
deep learning	8
information technology	8
retailing	8

Source: author's elaboration on the basis of R software.

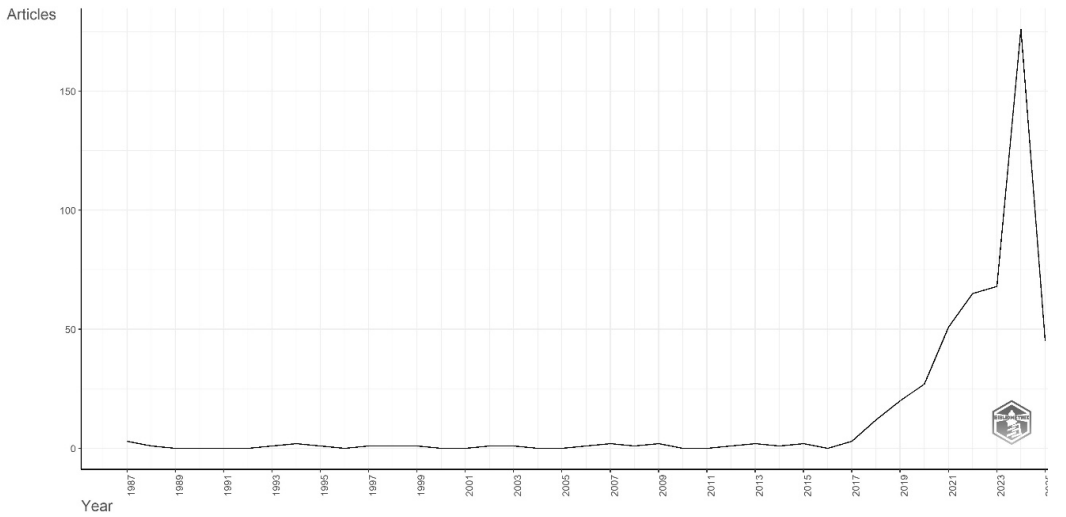

Fig. 2. Distribution of scientific publications in the thematic area of AI and marketing technologies in 1987-2025

Source: author's elaboration on the basis of R software.

In terms of thematic diversity, the corpus included 1,685 unique keywords, reflecting the complexity and interdisciplinary nature of the AI-MarTech research space. The dataset also comprised 31,817 cited references, indicating a dense citation network and robust knowledge base - key markers of maturity in an academic field (Leydesdorff, 2001).

Together, these indicators confirm that AI-driven marketing technologies constitute a rapidly evolving, globally relevant, and theoretically rich domain. The scope and structure of the data justify the use of advanced bibliometric mapping to uncover trends, influential contributors, and underexplored areas that warrant further scholarly attention. In particular, the data reveal a significant surge in publication activity during the period 2015-2025, with an average growth rate of 36.53 %, more than four times the rate observed across the entire study window. This sharp upward trend is illustrated in Fig. 2, which highlights a rapid acceleration of scholarly interest in AI-driven marketing technologies.

3.2. Thematic clusters and network analysis

3.2.1. Primary specification (Analysis 1)

The authors conducted a qualitative interpretation of clusters based on a clearly specified, replicable analytical pipeline. First, clusters were identified in Biblioshiny (Bibliometrix) using Clustering by Coupling with the following settings: Unit of Analysis = Documents; Coupling measured by = References (bibliographic coupling); Impact measure = Local Citation Score (LCS); Cluster labelling by = Index Keywords; Number of Units = 250; Min Cluster Freq. = 5; Labels per cluster = 3; Label size = 0.3. Next, in the qualitative stage, the authors examined for each cluster: (i) the Index Keywords label profile with conf % shares (as the cluster's semantic fingerprint), (ii) the freq/centrality/impact (LCS) metrics describing scale and network embedding, and (iii) the position within Callon's quadrants (motor/basic/niche/emerging) derived from the thematic map (centrality-density). The interpretation thus combined the content signature (dominant keywords) with structural embedding (centrality) and internal maturity (density/impact), enabling the authors to identify cluster roles (e.g., motor vs niche), their likely developmental trajectories (movement towards higher centrality via links to outcome metrics), and integration gaps (areas of high density but low centrality).

3.2.2. Comparative specification (Analysis 2)

For triangulation, the authors replicated the procedure with an alternative yet comparable configuration: Unit of Analysis = Documents; Coupling measured by = References; Impact measure = Global Citation Score (GCS); Cluster labelling by = Authors' keywords; Number of Units = 250; Min Cluster Freq. = 5; Labels per cluster = 3; Label size = 0.3. Holding the unit of analysis, coupling method, and thresholds constant while switching the impact metric (LCS -> GCS) and the labelling source (Index Keywords ->

Authors' keywords) provides a complementary perspective: the LCS/Index-Keywords view emphasises corpus-internal influence and algorithmically derived index terms, whereas the GCS/Authors'-keywords view foregrounds globally cited contributions and author-intended terminology. The side-by-side results improve interpretive robustness by revealing where conclusions are stable across specifications and where topic prominence is sensitive to impact and labelling choices.

To identify the core research themes and their interconnections within the AI-MarTech domain, a co-word analysis was conducted based on author keywords and index keywords fields. Using Biblioshiny's clustering algorithms, the study generated a co-occurrence network and performed Callon's centrality and density analysis to classify themes according to their strategic relevance and internal coherence.

Across the two specifications, the field's structure is stable: the AI-marketing core remains the most central cluster (Cluster 1: innovation 66.7 %, marketing 16.7 %, AI 9.5 %; n=111, centrality=0.496, impact=2.848 in LCS), with adoption (Cluster 2: technology adoption 62.5 %, AI 47.6 %, marketing 33.3 %; n=92, centrality=0.347, impact=1.458 LCS / 4.409 GCS) and market applications (Cluster 3: commerce 54.5 %, AI 23.8 %, marketing 27.8 %; n=36, centrality=0.306, impact=1.269 LCS / 2.604 GCS) forming the main flanking streams. What changes with configuration is perceived impact and labelling: using GCS + Authors' keywords amplifies the impact of adoption and digital/commerce (global resonance) and surfaces precise emergent terms (e.g., virtual influencers), whereas LCS + Index Keywords emphasise influence within the analysed corpus and aggregates emergents under broader notions (e.g., perception). Within this backbone, the thematic map delineates five clusters in the centrality-density space: besides the core (Cluster 1), Cluster 2 captures adoption dynamics, Cluster 3 operationalises value in commerce/digital marketing, and two smaller clusters mark early-stage lines of inquiry Cluster 4 centred on perception (75 %; n=7, centrality=0.189, impact=1) and Cluster 5 on generative AI/ChatGPT (n=4, centrality≈0.18-0.19, impact=1 LCS / 2.518 GCS). Notably, generative AI/ChatGPT remains low in centrality (an emerging theme) yet shows faster citation uptake under GCS, while the human-centred strand may appear as "perception" in Index-based labelling or as "virtual influencers/advertising effects" when Authors' keywords are used, underscoring how labelling sources shape the visibility of nascent topics (Tables 3-4).

The expanding corpus of publications on AI and MarTech unequivocally evidences intensifying scholarly interest in this domain. The five identified thematic clusters delineate an integrated knowledge axis, from innovation (Cluster 1), through adoption (Cluster 2), to implementation outcomes (Cluster 3) of AI in marketing. This core is complemented by two relatively nascent areas: human-centred mediators (Cluster 4) and a generative accelerator (Cluster 5). The practical implications are already clear: organisations deploying AI in marketing should develop technology maturity models, invest in governance and explainable AI (XAI), evaluate effects experimentally (A/B and quasi-experimental designs), and systematically report ROI and associated risks. Taken together, this configuration of thematic clusters opens a rich and diversified research agenda for both scholarship and managerial practice.

The table below synthesises the co-word analysis of the AI-MarTech literature, delineating five the-

Tab. 3. Clusters according to bibliographic links. Publications from 1987-2025 - primary specification (Analysis 1)

Description	Cluster	Number of publications	Centrality	Impact
marketing - conf 16.7 % artificial intelligence - conf 9.5 % innovation - conf 66.7%	1	111	0.496	2.848
artificial intelligence - conf 47.6 % marketing - conf 33.3 % technology adoption - conf 62.5 %	2	92	0.347	1.458
commerce - conf 54.5 % artificial intelligence - conf 23.8 % marketing - conf 27.8 %	3	36	0.306	1.269
artificial intelligence - conf 19 % marketing - conf 16.7 % perception - conf 75 %	4	7	0.189	1
chatgpt - conf 33.3 % generative artificial intelligence - conf 42.9 % ai - conf 13.3 %	5	4	0.190	1

Source: author's elaboration on the basis of R software.

Tab. 4. Clusters according to bibliographic links. Publications from 1987-2025 - comparative specification (Analysis 2)

Description	Cluster	Number of publications	Centrality	Impact
artificial intelligence - conf 36.4 % marketing - conf 22.9 % technology adoption - conf 87.5 %	1	92	0.347	4.409
virtual influencers - conf 100 % virtual influencer - conf 100 % advertising effects - conf 100 %	2	7	0.189	2.575
artificial intelligence - conf 14.3 % digital marketing - conf 62.5 % marketing - conf 22.9 %	3	36	0.306	2.604
artificial intelligence - conf 47.9 % marketing - conf 51.4 % technology - conf 55.6 %	4	111	0.496	2.661
chatgpt - conf 33.3 % generative artificial intelligence - conf 42.9 % ai - conf 13.3 %	5	4	0.183	2.518

Source: author's elaboration on the basis of R software.

matic clusters with their size (n), centrality, impact, and functional role in the thematic network. Cluster 1 functions as a motor theme, integrating innovation, AI applications, and marketing outcomes, and providing the conceptual-methodological scaffolding for the field. Cluster 2 constitutes a basic theme around technology adoption, linking sources of innovation (C1) to market outcomes (C3), while being strongly moderated by human-centred factors captured in Cluster 4 (trust, usability, and transparency). Cluster 3 reflects the operationalisation of value in commerce (recommendation, omnichannel, and conversational commerce); its high conceptual centrality indicates a transversal, integrating role and a trajectory towards motor-theme status. Cluster 4 represents a niche yet strategically important human-centred perspective that moderates adoption-outcome relationships. Cluster 5 captures the emerging generative-AI stream (LLMs (Large Language Models)/ChatGPT), acting as an accelerator for C1-C3 and elevating quality, safety, and compliance requirements associated with C4. Together, the clusters chart an innovation, adoption and outcomes pathway, with human factors and generative AI shaping its pace and governance (Table 5).

The thematic classification confirms that while core topics such as AI adoption and marketing innovation are well-established, important areas related to human-centred AI, emotional engagement, and ethical challenges remain underexplored. These findings support calls for a broader, more integrated research agenda that incorporates both technological and humanistic dimensions of AI implementation in marketing.

Further in-depth analysis of the thematic map, in relation to four areas: motor themes, basic themes, niche themes, and emerging or declining topics, allowed the authors to classify key concepts according to their importance in the structure of the discipline (centrality) and the degree of development (density).

- The data presented in the thematic map (Fig. 3), combined with the ranking analysis of Callon's centrality and density, allow for a more precise assessment of the importance of key concepts in the knowledge structure in the area of AI and marketing technologies. The highest centrality is achieved by the concept of commerce (centrality = 17.992; rank 11), which confirms its key role as a driving topic - well-developed and strongly related to other research areas. Similarly, high density (111.435; rank 10) indicates the intensive internal development of this topic. This is a surprising phenomenon, because in the importance of clusters, the concept of commerce appeared only in the 3rd thematic cluster - primary specification. The concept of artificial intelligence also holds a high position, which achieves a centrality of 12.943 (rank 10) and a density of 63.248 (rank 3), which confirms its role as a basic theme, i.e., strongly present in the structure but still being developed conceptually.
- In turn, sustainable development is characterised by a significantly lower centrality (8.695; rank 9) with a very high density (111.239; rank 9), which classifies it as a niche topic - well-developed, but with a limited integrative role in the knowledge system. Economic and social effects (centrality =

Tab. 5. Characteristics and significance of thematic clusters - based on the primary specification (Analysis 1)

Cluster	Main themes	n	Centrality	Impact	Profile and significance	Role and linkages	Stage and trajectories
1	marketing - conf 16.7 % artificial intelligence - conf 9.5 % innovation - conf 66.7 %	111	0.496	2.848	Largest, nodal cluster integrating the field's language: from innovation to AI applications to marketing outcomes; motor theme providing conceptual and methodological scaffolding for other streams.	Strong coupling with C2 (adoption) and C3 (commerce): innovation triggers implementation processes and materialises in market outcomes.	Mature, high-impact; shift towards platformisation and agentic systems (AI agents), standardisation of ROI metrics, governance and regulatory compliance.
2	artificial intelligence - conf 47.6 % marketing - conf 33.3 % technology adoption - conf 62.5 %	92	0.347	1.458	Organisational, behavioural stream: competencies, technological readiness, process fit, perceived value and risk.	Basic theme linking C1 (innovation sources) to C3 (outcomes); strongly moderated by C4 (trust, usability, transparency).	Consolidating; development of maturity models for AI adoption, effect measurement at process/team level; evidence-based adoption (A/B, quasi-experiments), change management.
3	commerce - conf 54.5 % artificial intelligence - conf 23.8 % marketing - conf 27.8 %	36	0.306	1.269	Market applications: recommendations, omnichannel, conversational commerce, retail media, path-to-purchase optimisation.	The concept "commerce" exhibits the highest centrality and high density at the concept-map level -> transversal integrator across clusters.	Moving towards motor theme; expansion of conversational commerce (LLM, semantic search, advisor agents), integration with supply chain and dynamic pricing, cross-channel attribution, privacy and compliance.
4	artificial intelligence - conf 19 % marketing - conf 16.7 % perception - conf 75 %	7	0.189	1	Human-centred perspective: attitudes, trust, acceptance, usability, emotion, ethics, AI disclosure.	Niche moderator of the C2 -> C3 relationship (adoption -> outcomes).	Early but high growth potential: XAI, disclosure, anthropomorphism, user control, cultural differences; longitudinal studies of emotion and trust.
5	chatgpt - conf 33.3 % generative artificial intelligence - conf 42.9 % ai - conf 13.3 %	4	0.19	1	Most emerging technical, methodological stream: LLMs, content generation, new interaction protocols (prompting), applications in marketing and commerce.	Accelerator for C1-C3; elevates the salience of C4 (quality, safety, ethics).	Transition from chatbots to agentic systems; multimodality; automation of creative work and campaign optimisation; quality-evaluation frameworks (guardrails, hallucinations, compliance).

1.458; density = 111.574), ranking only 5th in terms of centrality, despite its very high internal development (rank 11 in terms of density).

- According to the data, machine learning (centrality 6.696; density 66.865) and decision-making (centrality 4.894; density 89.672) should be considered as intermediate topics - developing and increasingly present, but not yet dominant. Customer service (centrality 1.604) also belongs to this group, although its relatively low cluster frequency (14) may indicate a limited number of studies.
- Among the emerging or marginal topics are concepts such as adversarial machine learning, delivery of health care, ecotourism and speech recognition - all characterised by zero centrality

Tab. 6. Key concepts and their importance in the research area - tabular presentation

Key concept	Callon's centrality	Callon density	Centrality ranking	Density ranking	Cluster frequency
commerce	17.992	111.435	11	10	241
artificial intelligence	12.943	63.248	10	3	263
Sustainable development	8.695	111.239	9	9	41
machine learning	6.696	66.865	8	4	27
decision making	4.894	89.672	7	7	86
customer service	1.604	87.5	6	6	14
economic and social effects	1.458	111.574	5	11	21
adversarial machine learning	0	50	2.5	1.5	2
delivery of health care	0	75	2.5	5	4
ecotourism	0	108.333	2.5	8	12
speech recognition	0	50	2.5	1.5	2

Source: author's elaboration on the basis of R software.

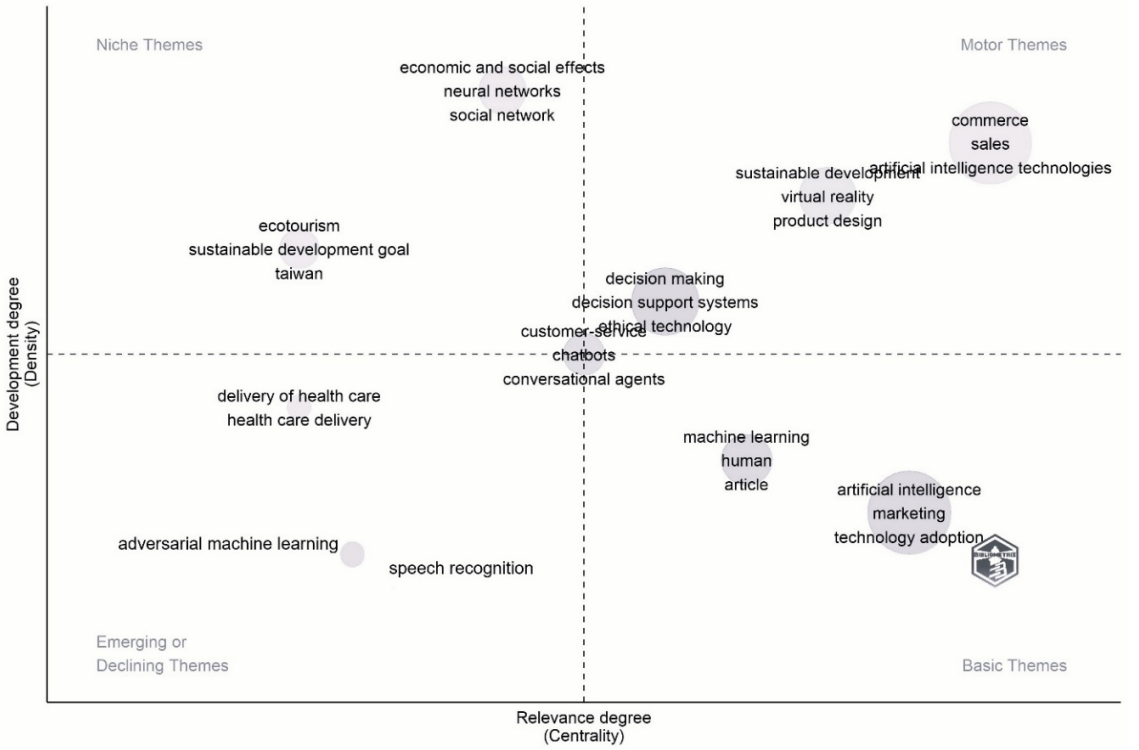

Fig. 3. Key concepts and their importance in the research area - tabular presentation

Source: author's elaboration on the basis of R software.

and low density, but appearing as new themes in the analysed literature (Table 6).

As an extension of the cluster-level results, the keyword analysis interpreted through Callon's centrality and density provides a qualitative lens on how specific concepts shape knowledge development in AI-MarTech and where they may steer future inquiry. By assessing each keyword's current network position (integrative relevance) and internal development (cohesion), the authors infer its prospective impact trajectory and the most promising linkages to outcome-oriented streams. The table below summarises these insights, reporting the metrics and the authors' succinct inferences ("Authors posit that") to indicate how research organised around each keyword is likely to evolve (Table 7).

Tab. 7. Keywords in the thematics clusters analysis, the author's perspective in the AI-MarTech domain

Keyword	Segment (Callon)	Current placement on the thematic map	Authors posit that
Commerce	Motor	Already a motor keyword; it bridges disparate themes and anchors outcome metrics.	it will retain its integrative role, with future studies deepening causal links to adoption and decision processes and standardising ROI - Return on Investment /attribution measures, thereby further increasing centrality.
Artificial intelligence	Basic	An infrastructural, corpus-wide keyword that still advances conceptually.	greater conceptual specification and typology building, coupled with tighter links to governance and outcomes, will raise internal cohesion (density) and consolidate its basic status.
Sustainable development	Niche	Well-developed locally, yet weakly integrative at the system level.	centrality will increase if sustainability frames are operationalised in adoption pathways and outcome metrics (e.g., carbon footprint of campaigns, eco-ROI - Return on Investment).
Economic and social effects	Niche	Locally mature but peripheral; measurement is uneven.	standardising indicator panels and deploying quasi-experimental designs will elevate centrality by connecting effects to the adoption-decision-commerce chain.
Machine learning	Intermediate	Growing and methodologically mature, but not yet dominant.	application-oriented studies (recommendation, personalisation) that tie ML interventions to decision processes and commerce outcomes will increase network centrality.
Decision-making	Intermediate	Internally developed; currently moderate connectivity.	it will strengthen as a mediating node as studies model mediation/moderation along the adoption-decision-commerce pathway.
Customer service	Intermediate (narrow)	Coherent but limited in scale and connectivity.	centrality will rise if embedded in omnichannel and conversational commerce and aligned with outcome metrics (NPS - Net Promoter Score, CLV - Customer Lifetime Value, conversion).
Adversarial machine learning	Emerging/Marginal	Early-stage and isolated within AI-MarTech.	it will gain traction once positioned within marketing risk and governance use-cases, including model robustness assessments in campaigns and personalisation.
Delivery of health care	Emerging/Marginal	Sector-specific and peripheral to MarTech.	it is likely to remain peripheral unless transferability tests (e.g., patient journey - customer journey) demonstrate relevance to mainstream AI-MarTech outcomes.
Ecotourism	Emerging/Marginal (locally consolidated)	Consolidated locally but disconnected from the core network.	centrality will increase only if insights are translated into mainstream marketing metrics and adoption routes.
Speech recognition	Emerging/Marginal	Early-stage; limited links to outcomes.	it may move towards the core as voice/multimodal commerce matures and is explicitly tied to measurable outcomes (conversions, retention).

3.3. Authors of publications and research centres

The conducted analysis of authors and research centres highlights the current situation regarding dominant researchers, universities and regions specialising in the analysed scope, i.e., AI and marketing technologies.

Assessing the activity of the authors, the leaders in terms of the number of articles are Dwivedi and Kumar. Each of them published five articles in the analysed period. They were followed by two researchers, Kim and Zhang, with four publications. The next large group consists of researchers with three articles and varying intensity of their citations (Table 8).

Tab. 8. Author productivity in 2019-2025

Author	Year	Frequency	Total citations	Total citations /year
AW EC-X	2024	1	11	5.5
AW EC-X	2025	2	0	0
BILGIHAN A	2020	1	18	3
BILGIHAN A	2024	2	21	10.5
BUHALIS D	2019	1	533	76.143
BUHALIS D	2023	1	1819	606.333
BUHALIS D	2024	1	11	2.5
DATA COSTA RL	2022	2	10	2.5
DATA COSTA RL	2023	1	3	1
DIAS A	2022	2	10	5.5
DIAS A	2023	1	3	1
DWIVEDI YK	2021	1	128	25.6
DWIVEDI YK	2023	2	1881	627
DWIVEDI YK	2024	1	11	5.5
DWIVEDI YK	2025	1	0	0
GONÇALVES R	2022	2	10	2.5
GONÇALVES R	2023	1	3	1
WHO M	2022	1	40	10
WHO M	2024	3	5	2.5
KUMAR V	2019	1	406	58
KUMAR V	2021	1	239	47.8
KUMAR V	2024	3	75	37.5
ZHANG J	2021	1	62	12.4
ZHANG J	2023	1	5	1.667
ZHANG J	2024	2	14	7

Source: author's elaboration on the basis of R software.

The analysis of authors' citations in the context of years of publication and the number of works published annually does not show any significant differences between the authors studied. Significant differentiation occurs at the level of the number of citations and clearly indicates the presence of authors with a dominant citation position and those whose scientific influence is relatively low.

The most influential authors in terms of citations work scientifically at universities in the UK. They are Buhalis, Dwivedi, and Mogaji. Dimitrios Buhalis, professor of marketing, strategy and innovation at Bournemouth University in the UK, has the highest number of citations (TC = 2363). His works are very popular in the scientific community, despite a lower Hirsch index (3). Yogesh K. Dwivedi, professor of digital marketing and innovation at Swansea University in the UK (h_index = 4, g_index = 5, m_index = 0.8, TC = 2020), started publishing in 2021 and has already obtained an impressive number of citations. His research topics touch, among others, on contemporary marketing challenges in the area of social media and the metaverse. Dr Emanuel Mogaji works at the University of Keele in the UK (TC = 2054) and works in marketing. Despite his relatively low H-index (3), his publications have a high number of citations, which suggests that he has several very influential articles (Table 8-9).

Another interesting aspect in the context of the authors is their willingness to cooperate with partners outside their own country. Considering the map of international cooperation of all the authors, differences can be observed between countries in terms of openness to conducting research outside their coun-

Tab. 9. Analysis of the most influential authors of research and scientific publications

Author	h_index	g_index	m_index	Total Citations (TC)	Number of publications (NP)	Year of publication commencement
KUMAR V	5	5	0.714	720	5	2019
DWIVEDI YK	4	5	0.8	2020	5	2021
BUHALIS D	3	3	0.429	2363	3	2019
DA COSTA RL	3	3	0.75	13	3	2022
DIAS Á	3	3	0.75	13	3	2022
GONÇALVES R	3	3	0.75	13	3	2022
LEE J	3	3	0.6	57	3	2021
MOGAJI E	3	3	0.6	2054	3	2021
PEREIRA L	3	3	0.75	13	3	2022
PUNTONI S	3	3	0.6	535	3	2021

Source: author's elaboration on the basis of R software.

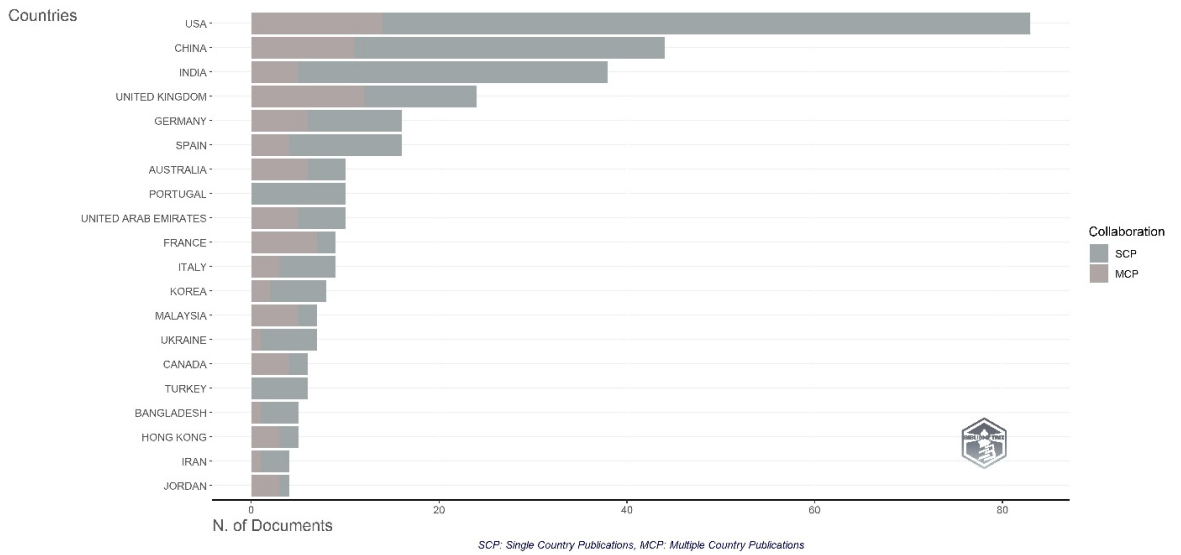

Fig. 4. Map of the authors' international cooperation, the examined period 1987-2025

Source: author's elaboration on the basis of R software.

tries. The greatest openness to international cooperation is shown by research centres from Great Britain, Australia, France, Canada, Malaysia, and Jordan. The remaining centres, especially the most productive ones from the United States, China, and India, remain largely at the level of their domestic research, limiting scientific cooperation to their region (Fig. 4).

3.4. Leading research institutions and university contributions

Although the most influential authors of publications are researchers from Great Britain, the largest number of publications per academic centre comes from Australian universities. The five most active universities in terms of publications are: Queensland University of Technology in Australia (14 publications), UCSI University in Malaysia (10 publications), Swansea University in Great Britain (9 publications), The Hong Kong Polytechnic University (9 publications) and Auckland University of Technology in New Zealand (8 publications) (Table 10).

When analysing the specificity of scientific research conducted by the five top-mentioned universities, it is worth emphasising that all of these universities have a strong research specialisation in

Tab. 10. University centres and their productivity in 1987-2025

LP.	University centre	Articles
1	QUEENSLAND UNIVERSITY OF TECHNOLOGY	14
2	UCSI UNIVERSITY	10
3	SWANSEA UNIVERSITY	9
4	THE HONG KONG POLYTECHNIC UNIVERSITY	9
5	AUCKLAND UNIVERSITY OF TECHNOLOGY	8
6	GRIFFITH UNIVERSITY	8
7	INSTITUTO UNIVERSITÁRIO DE LISBOA	8
8	NORTHEASTERN UNIVERSITY	8
9	UNIVERSITY OF GRANADA	8
10	KHMELNYTSKYI NATIONAL UNIVERSITY	7
11	NORTH CHINA UNIVERSITY OF WATER RESOURCES AND ELECTRIC POWER	7
12	UNIVERSITY OF NORTH TEXAS	7
13	UNIVERSITY OF ZILINA	7
14	YONSEI UNIVERSITY	7
15	AARHUS UNIVERSITY	6
16	FLORIDA STATE UNIVERSITY	6
17	KOREA UNIVERSITY	6
18	MOHAMMED VI POLYTECHNIC UNIVERSITY	6
19	NATIONAL INSTITUTE OF INDUSTRIAL ENGINEERING (NITIE)	6
20	SYMBIOSIS INTERNATIONAL (DEEMED UNIVERSITY)	6
21	TRANSILVANIA UNIVERSITY OF BRAȘOV	6
22	XI'AN UNIVERSITY OF SCIENCE AND TECHNOLOGY	6
23	JINAN UNIVERSITY	5
24	NANYANG TECHNOLOGICAL UNIVERSITY	5
25	NATIONAL TAICHUNG UNIVERSITY OF SCIENCE AND TECHNOLOGY	5

Source: author's elaboration on the basis of R software.

each of the three areas, i.e., AI, management, and marketing.

Queensland University of Technology has a strong research background in data science, AI, and digital marketing. The university is known for its practical and implementation approach - exploring the application of AI in real-world marketing scenarios. The Social Marketing (Research Group) aims to develop and integrate marketing concepts with other approaches, including in relation to the digital world, to drive behavioural change and social transformation that benefits consumers, society and the planet (source: https://research.qut.edu.au/social-marketing-research-group/).

UCSI University in Malaysia actively collaborates with government programmes to develop AI research. UCSI University has partnered with RICOH Malaysia to establish an IT research and development lab equipped with modern equipment. This lab is intended for postgraduate and final year IT students, which promotes AI research and digital innovation (source: https://www.ucsiuniversity.edu.my/ucsi-university-and-ricoh-malaysia-establish-partnership-to-create-research-and-development-lab).

When analysing the reasons for the high productivity of Swansea University in the UK, several factors can be seen that contribute to this situation. First, the university collaborates with renowned researchers,

including Professor Yogesh Dwivedi, who, as previously mentioned in the authors' analysis, is an influential authority on scientific publications in the area of AI in marketing. The university develops research topics in the field of digital consumer behaviour, MarTech, and the digital transformation of organisations. The university has a research unit, the Centre for Digital Economy, which combines research on AI, e-commerce, and management.

The Hong Kong Polytechnic University is one of the most active universities in this country, developing programmes in business intelligence, AI, e-commerce, and marketing management. Hong Kong, as a key technology hub, supports and finances cooperation with universities. An additional favourable aspect for the development of applied research and publications is the functioning of a large network of startups with which this university cooperates.

The last university in the top five is the Auckland University of Technology from New Zealand, which conducts a lot of research around AI. It focuses on the ethical and social aspects of technology development. The university promotes a human-centred approach to AI - especially in the context of the impact of technology on consumer behaviour. It can be assumed that this is one of the future research trends, considering the above-described thematic clusters.

3.5. Geographic analysis of publication counts and scientific impact in the field of AI and marketing technologies

The analysis of the number of scientific publications by country shows the dominant position of the United States (275 publications), which has the longest and most developed research and business ecosystem supporting innovations in the field of artificial intelligence and marketing technologies. The next positions are occupied by India (150) and China (147) - countries that are dynamically developing the digital sector, supported by both government policies and the growing number of specialists in the field of data science and MarTech. Great Britain (86) also demonstrates high scientific activity, benefiting from strong academic centres and numerous international partnerships.

Complementing the quantitative analysis, the breakdown reveals interesting differences in the scientific impact of publications, measured by the number of citations per article on average. The highest average number of citations per article is achieved by the United Kingdom (137.9), which indicates high quality and influence of a smaller number of publications. In comparison, the USA - although leading in the number of documents - achieves an average of 33.1 citations per article, which may indicate a wider range of quality or a greater share of publications with an applied character. High average citations are also recorded by France (92.4), Australia (62.5), Switzerland (62.2), and Ireland (65.0), which confirms their specialisation in niche but highly valued research topics.

In turn, China (18.0), the United Arab Emirates (16.1), and India (35.9) are characterised by a lower average citation rate, despite a large number of publications, which may indicate a greater focus on quantity than on international scientific impact. Ukraine (7.1) and Bangladesh (8.4) draw particular attention - despite high activity in the number of documents, their impact measured by citations is relatively low.

Poland, although not among the top publications, ranks 17th out of 72 countries (35 positions listed in Table 11), and appears in the ranking with 34 citations and an average of 8.5 per article, which may indicate a growing, but still limited, involvement in the global academic debate on AI and MarTech.

The findings suggest that the number of publications does not always correlate with their impact. Countries such as the UK, France and Australia show that strategic and well-grounded research can be more important than mass production of content. In addition, the data underscore the importance of the quality of scientific collaboration, the reputation of research centres and the specificity of the topics addressed by researchers (Table 11).

Interestingly, while the United States dominates in total publication volume, it is the United Kingdom that ranks highest in average citation impact per article. This suggests a strategic focus on theoretical contributions and global relevance, despite producing fewer total documents.

The geographic distribution of institutions also reflects the global nature of AI-MarTech research, with notable activity across Europe, Asia-Pacific, and North America. Furthermore, several smaller countries, such as the Netherlands, Belgium, and Singapore, exhibited disproportionately high citation impact, often attributable to international research collaborations and interdisciplinary projects.

Taken together, these findings highlight the critical role of a small number of globally engaged universities in advancing the AI-MarTech research agenda. Their influence is amplified by strong international networks and a clear alignment with strategic research

Tab. 11. Number of publications and citations per country

LP.	Country	Number of publications
1	USA	275
2	INDIA	150
3	CHINA	147
4	UK	86
5	SPAIN	57
6	UKRAINE	55
7	AUSTRALIA	51
8	ITALY	47
9	PORTUGAL	43
10	GERMANY	39
11	SOUTH KOREA	33
12	FRANCE	31
13	MALAYSIA	30
14	JORDAN	24
15	NEW ZEALAND	23
16	ROMANIA	23
17	POLAND	20
18	FINLAND	18
19	SAUDI ARABIA	18
20	UNITED ARAB EMIRATES	18
21	CANADA	17
22	INDONESIA	16
23	TURKEY	16
24	SINGAPORE	15
25	BANGLADESH	13
26	IRAN	13
27	SLOVAKIA	12
28	GREECE	11
29	MEXICO	10
30	SWITZERLAND	10
31	ISRAEL	9
32	DENMARK	8
33	NETHERLANDS	8
34	SWEDEN	8
35	CROATIA	7

LP.	Country	Total citations	Citations per article
1	UNITED KINGDOM	3 309	137.88
2	USA	2 748	33.11
3	INDIA	1 366	35.95
4	SPAIN	903	56.44
5	FRANCE	832	92.44
6	GERMANY	827	51.69
7	CHINA	792	18.00
8	AUSTRALIA	625	62.50
9	PORTUGAL	381	38.10
10	KOREA	316	39.50
11	ITALY	260	28.89
12	SWITZERLAND	249	62.25
13	MALAYSIA	229	32.71
14	HONG KONG	221	44.20
15	CANADA	202	33.67
16	FINLAND	179	59.67
17	AUSTRIA	95	47.50
18	IRELAND	65	65.00
19	SWEDEN	64	32.00
20	SINGAPORE	63	15.75
21	MEXICO	61	15.25
22	IRAN	58	14.50
23	NETHERLANDS	58	14.50
24	LITHUANIA	57	28.50
25	DENMARK	53	26.50
26	UKRAINE	50	7.14
27	JAPAN	42	42.00
28	BANGLADESH	42	8.40
29	ROMANIA	41	13.67
30	POLAND	34	8.50
31	NEW ZEALAND	27	6.75
32	TURKEY	20	3.33
33	MOROCCO	17	17.00
34	SRI LANKA	11	5.50
35	GEORGIA	10	3.33

Source: author's elaboration on the basis of R software.

priorities in marketing, data science, and digital innovation.

3.6. Analysis of the most influential global publications

The analysis of documents with the highest citations indicates a clear dominance of articles by Dwivedi, who achieved 1,819 total citations in 2023 and an impressive average of 606.33 citations per year, making it both the most influential and the fastest gaining recognition of scientific texts in the area of AI and marketing technologies. The articles by Hoyer (article from 2020), Buhalis (from 2019), and Wamba-Taguimdje (from 2020) also stand out with a high number of citations - all exceeding the threshold of 500 citations, which proves their significant contribution to the development of literature. The publication by Puntoni (2021) also draws special attention, with a total number of 496 citations, recording an average of 99.2 citations per year, confirming the relevance and practical importance of the subject matter.

The annual citation breakdown clearly shows which publications have gained the fastest resonance in the scientific community, making them an important reference for further research. This indicates the dynamic development of the research field after 2020, especially in the context of the growing importance of artificial intelligence in digital marketing, building customer experiences and the transformation of management models. Moreover, publications from 2019-2021, despite their relatively short time in the scientific circulation, achieve comparable or higher citation rates than older works, which confirms the acceleration of researchers' interest in AI and MarTech in recent years (Table 12).

Tab. 12. Analysis of the Top 25 influential publications based on the number of citations

LP.	Authors / Articles	Total citations	Citations/year	Normalised citation count
1	DWIVEDI YK, 2023, INT J INF MANAGE	1819	606.33	42.30
2	HOYER WD, 2020, J INTERACT MARK	542	90.33	4.67
3	BUHALIS D, 2019, J TRAVEL TOUR MARK	533	76.14	4.67
4	WAMBA-TAGUIMDJE SL, 2020, BUS PROCESS MANAGE J	502	83.67	4.33
5	PUNTONI S, 2021, J MARK	496	99.20	6.39
6	BELANCHE D, 2019, IND MANAGE DATA SYS	419	59.86	3.67
7	KUMAR V, 2019, CALIF MANAGE REV	406	58.00	3.56
8	VERMA S, 2021, INT J INF MANAG DATA INSIGHTS	377	75.40	4.86
9	ALMEIDA F, 2020, IEEE ENG MANAGE REV	326	54.33	2.81
10	PORIA S, 2014, KNOWL BASED SYST	275	22.92	1.00
11	STEINHOFF L, 2019, J ACAD MARK SCI	252	36.00	2.21
12	KUMAR V, 2021, J BUS RES	239	47.80	3.08
13	RUST RT, 2020, INT J RES MARK	217	36.17	1.87
14	QUACH S, 2022, J ACAD MARK SCI	211	52.75	5.67
15	PILLAI R, 2020, BENCHMARKING	208	34.67	1.79
16	YIGITCANLAR T, 2020, SUSTAINABILITY	187	31.17	1.67
17	SAURA JR, 2021, IND MARK MANAGE	172	34.40	2.22
18	CHINTALAPATI S, 2022, INT J MARK RES	171	42.75	4.59
19	CLOSS DJ, 2008, J OPER MANAGE	169	wrz.39	1.00
20	HAMILTON R, 2021, J MARK	167	33.40	2.15
21	SAMALA N, 2022, J TOUR FUTUR	161	40.25	4.33
22	DE BELLIS E, 2020, J RETAIL	156	26.00	1.34
23	MANSER PAYNE EH, 2021, J RES INTERACT MARK	155	31.00	2.00
24	MANSER PAYNE EH, 2021, J RES INTERACT MARK	137	27.40	1.77
25	YIGITCANLAR T, 2020, J OPEN INNOV: TECHNOL MARK COMPLEX	134	22.33	1.15

Source: author's elaboration on the basis of R software.

3.7. Cited source analysis by year of publication (RPYS)

Results of the spectroscopy analysis of the publication years of the cited sources (Reference Publication Year Spectroscopy) clearly indicate that research in the area of artificial intelligence and marketing technologies is based primarily on current scientific literature. The vast majority of cited works come from the period 2000-2022, with a particularly intensive increase in citations observed in the years 2015-2021. This means that the theoretical foundations and the development of tools and methods in this field have been dynamically shaped in the last decade.

Analysis of deviations from the five-year median of citations (light grey line in Fig. 5) reveals significant increases in the years 2016-2019, which can be interpreted as moments of publication of breakthrough works, in the field of artificial intelligence (e.g., deep learning, machine learning, and NLP) and their applications in digital marketing and shaping customer experience. At the same time, the marginal number of citations of older sources (pre-2000) confirms that this field is modern in nature and strongly related to technological development, and traditional management or marketing concepts are rarely invoked here.

The conclusions from RPYS emphasise that AI in marketing is a relatively young but rapidly growing research area, in which fresh and interdisciplinary sources of knowledge are crucial. It is also a hint for future researchers to pay special attention to the literature developed in the last 5-10 years as a foundation for further theoretical and empirical analyses.

Building on the citation-structure analysis presented above, the authors consider the following qualitative inferences to be salient: (i) a structural recency dependence in AI-MarTech, whereby rapid methodological turnover and tool diffusion after 2015 render older contributions progressively less central; (ii) a short method -> application lag, with the 2016-2019 spikes consistent with breakthroughs in core AI (e.g., deep learning and NLP) being followed by accelerated uptake in digital marketing and customer-experience contexts, a proposition that is testable via time-sliced RPYS and cross-correlations between method-centric and application-centric citation series; and (iii) the low salience of pre-2000 sources, which suggests limited path-dependence on legacy marketing theory and lagging diffusion of governance and human-centred concerns (trust, usability, perceived risk, and ethics), motivating longitudinal tracking (e.g., rolling five-year windows) to observe when these themes integrate into outcome-oriented research.

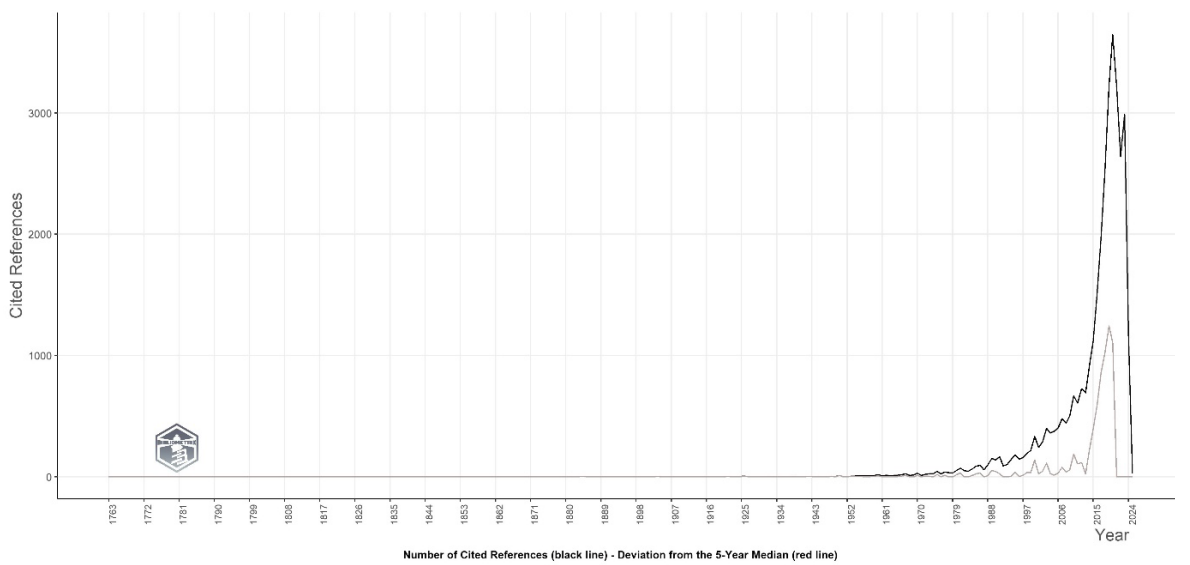

Fig. 5. Analysis of cited sources by year of publication

Source: author's elaboration on the basis of R software.

3.8. Authors' keyword analysis in AI and marketing technology publications

The analysis of the frequency of keywords used by the authors clearly indicates that "artificial intelligence" (233 occurrences) is definitely the dominant research topic in the analysed literature. The high frequency of this concept - in different spelling variants (including "AI" - 29 times, "artificial intelligence (AI)" - 21 times, "machine learning" - 30 times, "generative AI" - 11 times) - indicates the central place of artificial intelligence in research on the border between marketing and new technologies.

The general term "marketing" (56) came second, followed by the more specialised term "digital marketing" (33), confirming that the area of digital marketing is the main context for AI applications. A significant number of occurrences also concern related technologies and concepts, such as "big data" (19), "internet of things" (14), "ChatGPT" (15), "chatbots" and "chatbot" (17 in total), "deep learning" (8) or "augmented reality" (7), which proves the interdisciplinary nature of the analysed area.

Emerging keywords such as "technology adoption" (12), "digital transformation" (10), and "customer experience" (10) suggest that research focuses not only on the technology itself, but also on the process of its implementation and its impact on consumer experience. Additionally, the presence of the terms "social media" (12), "advertising" (7) and "e-commerce" (7) indicates strong links between AI and the areas of application in digital communication and sales.

Taken together, the results of this analysis confirm that AI in marketing is a complex, dynamic topic, deeply embedded in the realities of contemporary digital transformation, encompassing technological, consumer, communication and strategic issues.

The authors' reading of the keyword distribution may suggest a three-layer structure of the AI-MarTech discourse. First, an infrastructural, computational layer appears to coalesce around the family of terms related to artificial intelligence (artificial intelligence, AI, artificial intelligence (AI), machine learning, generative AI, and ChatGPT), complemented by big data, the internet of things, deep learning, and augmented reality. This concentration may be taken to indicate an AI-centric identity for the field, in which the technical backbone provides methods and data substrates for marketing applications. Second, an application layer (including marketing, digital marketing, social media, advertising, e- commerce, retailing, and customer/client experience) appears to suggest that AI is predominantly framed in service of market outcomes and customer-facing processes rather than as an end in itself. Third, an organisational-implementation layer (technology, innovation, technology adoption, adoption, and digital transformation) may indicate growing attention to how AI is embedded within firms and workflows, not only what it does.

Tab. 13. Keywords analysis of article authors

LP.	Authors' keywords	Occurrence
1	Artificial intelligence	233
2	Marketing	56
3	Digital marketing	33
4	Machine learning	30
5	AI	29
6	Technology	26
7	Artificial intelligence (ai)	21
8	Big data	19
9	Chatgpt	15
10	Internet of things	14
11	Innovation	12
12	Social media	12
13	Technology adoption	12
14	Tourism	12
15	Generative AI	11
16	Generative artificial intelligence	11
17	Covid-19	10
18	Client experience	10
19	Digital transformation	10
20	Adoption	9
21	Chatbots	9
22	Chatbot	8
23	Deep learning	8
24	Information technology	8
25	Retailing	8
26	Social media marketing	8
27	Advertising	7
28	Augmented reality	7
29	Digital technologies	7
30	ecommerce	7

Source: study by the author in R software, Scopus database.

Within this configuration, the simultaneous presence of ChatGPT/generative AI and chatbot(s) may point to evolution rather than rupture: conversational interfaces likely persist, while underlying models shift towards large-scale paradigms. The occurrence of tourism and COVID-19 may reflect sectoral and temporal sub-streams; their moderate frequencies could suggest context-specific lines of inquiry rather than field-defining pillars. From a maturity perspective, the relatively high frequencies of umbrella labels (e.g., artificial intelligence and marketing) compared with more granular constructs (e.g., advertising and customer experience) are consistent with the view that the domain is consolidating around higher-order categories while differentiating mechanisms and outcomes in parallel. Notably, the limited visibility of governance/ethics vocabulary (e.g., trust, transparency, and fairness) among the most frequent terms may signal - at least in this sample - an underrepresentation of normative and risk-management concerns at the top of the frequency distribution.

In light of these observations, the authors suggest as a promising direction for future research the systematic linking of the implementation layer (adoption and digital transformation) with outcome constructs (e-commerce, advertising, and customer experience), coupled with the early integration of quality and safety dimensions (e.g., transparency and reliability). Such a shift would allow the literature to move beyond frequency counts towards explanatory models of impact.

4. Discussion of the results

Based on the bibliometric analysis, it can be concluded that the state of research on artificial intelligence in the context of marketing technologies (research question PB1) is at a stage of dynamic development, especially after 2020. The literature covers a wide spectrum of AI applications - from process automation, through personalisation of marketing activities, to the development of generative AI and recognition of customer emotions. The evolution of the literature (research question PB2) shows a clear shift in researchers' interests from the tool level (e.g., machine learning and big data) to topics related to customer experience, AI ethics and emotion-based communication. Particularly intensive development of the literature took place in 2019-2023, which is reflected both in the number of publications and average citations per article.

Among the leading research centres (research question PB3), Queensland University of Technology, Swansea University, The Hong Kong Polytechnic University and UCSI University stand out, which not only generate a large number of publications but also actively participate in international research projects. The largest number of publications comes from the United States, India, and China, while the highest average citation impact is recorded by research conducted in the United Kingdom, France, and Australia.

The analysis also allows for the identification of existing gaps and limitations of the literature (research question PB4), among which the fragmentation of theoretical approaches, the insufficient number of empirical studies in the context of AI applications in various industries and the insufficient consideration of ethical and social aspects come to the fore. Possibilities for further research include human-centred AI development, AI integration with customer experience management (Customer Experience, in short CX), creating real-time predictive models and exploring emotional aspects of marketing communication. The identified areas constitute important directions for future research exploration and market practices.

The bibliometric evidence positions AI-MarTech as a rapidly advancing yet already structured domain. A stable backbone, an AI-marketing core flanked by technology adoption and market applications/digital commerce, organises the literature, while human-centred factors and generative AI/ChatGPT remain early-stage but increasingly consequential. RPYS confirms strong recency, consistent with fast methodological turnover. Beyond mapping, this study contributes a unifying field architecture (innovation -> adoption -> outcomes), a measurement-sensitive triangulation (constant coupling/thresholds with LCS vs GCS and Index vs Authors' keywords), and keyword-level diagnostics that identify commerce as the most central transversal integrator and AI as an infrastructural "basic" theme, with high-density yet peripheral niches (sustainability and economic/social effects) poised for integration. Going forward, further research should (i) model causal chains from adoption to decision-making to outcomes using A/B and quasi-experiments and standardised metrics (ROI, incrementality, CLV, and retention), (ii) bridge high-density niches to outcome streams, and (iii) develop governance for generative AI (guardrails, disclosure

and XAI) explicitly tied to measurable impact. These conclusions provide a decision-relevant baseline for cumulative theory building and empirical work in AI-MarTech.

Conclusions

This article maps the AI-MarTech literature using a transparent, replicable bibliometric pipeline over 492 peer-reviewed publications (1987-2025). The field exhibits a stable backbone with an AI-marketing core (the largest and most central), flanked by technology adoption and market applications/digital commerce. Two smaller clusters: human-centred factors and generative AI/ChatGPT are early-stage in network terms but increasingly consequential, reflecting a shift towards governance, trust, and safety alongside performance. Beyond description, the study contributes (i) an integrative field architecture, innovation -> adoption -> outcomes, linking fragmented streams; (ii) measurement-sensitive triangulation (constant coupling/thresholds, varied impact metric: LCS vs GCS; varied label source: Index vs Authors' keywords) that shows how specification choices alter perceived salience (e.g., perception vs virtual influencers); and (iii) keyword-level diagnostics identifying commerce as the most central transversal integrator and AI as an infrastructural "basic" theme, with high-density yet peripheral niches (sustainability; economic/social effects) poised for integration. These results provide a robust baseline for cumulative theory building and decision-relevant empirical work.

Scientific contribution and research agenda

The authors' findings AI-MarTech as a substantive and fast-consolidating domain with a coherent field architecture. Empirically, the study articulates and supports a three-stage spine: innovation -adoption -market outcomes, augmented by human-centred moderators (trust, usability, perceived risk, and ethics) and a generative-AI accelerator that increasingly conditions speed and governance of diffusion. This integrative framing reconciles previously fragmented streams by positioning the AI-marketing core as the system's hub and by specifying how adjacent lines of inquiry (adoption processes and market applications) connect to outcome metrics. In parallel, keyword-level diagnostics clarify functional roles within the network: commerce operates as a transversal integrator (highest centrality), artificial intelligence functions as an infrastructural "basic" theme, while sustainability and economic/social effects appear as high-density yet peripheral niches that are poised for integration with outcome-oriented research. The temporal profile (post-2015 surge) and the geography of contributions further contextualise the evidence base, distinguishing volume leaders from high-impact ecosystems and, thus, informing collaboration strategies and external validity.

A second scientific contribution is measurement-sensitive triangulation. Holding the coupling method and thresholds constant while varying the impact metric (LCS vs GCS) and the label source (Index vs Authors' keywords) demonstrates how specification choices shift perceived salience. Under GCS + Authors' keywords, adoption and digital/commerce gain visibility and emergent topics are labelled with greater precision (e.g., virtual influencers), whereas LCS + Index Keywords emphasises influence within the analysed corpus and aggregates emergent under broader notions (e.g., perception). This dual-specification design provides a template for robustness checks in bibliometric mapping and encourages transparent reporting practices in future studies.

Taken together, these results yield a focused research agenda. First, move from adoption to outcomes by modelling causal chains, adoption -> decision-making -> commerce, using A/B and quasi-experimental designs, panel data, and robustness checks that link interventions to ROI, incrementality, CLV, retention, and related performance indicators. Second, bridge high-density niches to the core by operationalising sustainable development and economic/social effects with comparable outcome metrics (e.g., eco-ROI and robustness/fairness scores), thereby elevating their network centrality through explicit links to commerce and customer experience. Third, advance the governance of generative AI by developing guardrails, hallucination audits, disclosure practices, and XAI protocols, and by tying quality and safety directly to measurable market outcomes; track when generative AI transitions from an emergent theme to a motor theme. Fourth, scale human-centred moderators through cross-cultural, longitudinal designs on trust, usability, emotion, perceived risk, and ethics; use both Index- and author-labelled lenses to capture broad and fine-grained human factors. Fifth, pursue methodological pluralism with transparency by reporting dual impact

metrics (LCS and GCS) and dual labelling sources (Index and Authors' keywords) to separate stable signals from specification-sensitive patterns; where feasible, preregister bibliometric protocols. Finally, conduct sector-specific transfer tests for emergent/peripheral topics (e.g., virtual influencers, speech recognition), connecting sectoral insights to mainstream metrics (conversion, average order value, churn) to move these themes towards the field's core.

The scholarly payoff of this programme is threefold: it sharpens construct clarity around AI-MarTech, standardises evaluation across studies, and tightens the linkage between human-centred governance and economic value. In doing so, it provides a robust baseline for cumulative theory building and decision-relevant evidence that can guide both academic inquiry and managerial practice.

Limitations

As with all bibliometric studies, this research is subject to several limitations that should be acknowledged when interpreting the findings.

First, the analysis was limited to two major academic databases, Scopus and Web of Science, which, despite their breadth and credibility, do not capture the entirety of relevant literature. Important insights published in monographs, book chapters, or regional journals not indexed in these databases may have been omitted. Additionally, only English-language publications were considered, potentially excluding valuable contributions from non-English-speaking academic communities.

Second, the bibliometric indicators used, such as citation counts, centrality, and density, measure structural influence, but not necessarily conceptual depth or practical impact. Highly cited papers may reflect early interest rather than long-term theoretical contribution, while emerging themes might be undervalued due to their novelty.

Third, the keyword-based search strategy, although rigorously developed, may have excluded works that address AI and MarTech indirectly or under alternative terminologies. This could have affected the inclusivity of thematic clusters.

Despite these limitations, the study provides a strong empirical foundation for future research. Subsequent investigations should complement bibliometric approaches with qualitative content analysis, systematic reviews, or meta-analyses to explore conceptual relationships in greater depth. Future research may also address the ethical, emotional, and regulatory implications of AI in marketing, especially in light of developments in generative AI, human-AI interaction, and data privacy.

Such directions will contribute to a more integrated understanding of the technological, organisational, and societal dynamics shaping the evolution of AI-powered marketing ecosystems.

Practical implications

The findings carry several decision-relevant implications for marketing professionals, technology developers, and policy makers operating at the AI-MarTech interface. First, the identification of five thematic clusters, anchored in an AI-marketing core and flanked by technology adoption and digital-commerce, with human-centred factors and generative AI/ChatGPT as early-stage streams, offers a prioritisation map for capability building and investment. Mature areas should be targeted for near-term deployment, while emergent streams merit measured experimentation and structured monitoring.

Second, the rise of generative AI together with human-centred approaches underscores that performance gains must be coupled with governance and experience quality. Practitioners should integrate technical capacities (e.g., machine learning and NLP) with explainability, disclosure, and transparency mechanisms, and evaluate interventions using standardised outcome metrics (e.g., ROI, incrementality, CLV, and retention) and field experiments (A/B and quasi-experimental designs).

Third, the international distribution of impactful research, particularly contributions from the UK, France, Australia, and dynamic Asian ecosystems, suggests that cross-border partnerships with universities and R&D centres can accelerate transfer from method to application. Firms may benefit from co-developing evaluation protocols (e.g., shared benchmarks, reproducible pipelines) that reflect both global citation resonance and domain-specific constraints.

Finally, the observed underrepresentation of ethical and societal considerations implies that effective MarTech deployment should extend beyond technological efficiency to long-term stakeholder trust, data governance, and regulatory compliance. Establishing guardrails for generative AI (e.g., hallucination audits, risk registers, and XAI practices) and linking them explicitly to market outcomes can align innovation speed with safety and accountability.

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Navigating servitisation in the GCC fashion sector: a comprehensive assessment of status and barriers

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ABSTRACT

This study aims to evaluate the current level of servitisation in the Gulf Cooperation Council (GCC) markets in the fashion sector and identify various internal and external obstacles that may hinder fashion organisations in the GCC region from fully adopting the servitisation strategy. An exploratory methodology was employed, using a qualitative approach with semi-structured interviews on a purposive sample. The study reveals that the implementation of the servitisation strategy in GCC is in its initial stages. While evidence of the dimensions underlying such a strategy was found, they were not employed and linked as suggested in the literature to generate the required results. Additionally, non-transparent and limited relationships with partners and unskilled employees were identified as the main barriers preventing fashion agents from fully embracing servitisation in the GCC fashion sector. This study uniquely explores servitisation in the GCC fashion sector, filling a significant gap in existing research that has largely overlooked this region and industry. Unlike previous works that broadly address servitisation in manufacturing, this paper delves into the specific challenges and adoption levels within the GCC's culturally and economically distinct context. By offering nuanced insights from senior managers in leading fashion organisations, it provides valuable empirical evidence and practical implications for both academia and industry, marking a notable contribution to the literature on servitisation strategies in emerging markets.

KEY WORDS

product service system, service implementation barriers, performance measurement, supplier relationship, luxury products

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Introduction

The shift in focus of manufacturing organisations to deliver services alongside their products has become highly descriptive, replicating state-of-the-art practices in global production and consumption/usage trends (Pigosso & McAloone, 2016; Jaiswal & Ha-Brookshire, 2020; Zhao & Wang, 2021). This strategic transformation, referred to as the product-service system or "servitisation", delivers value to customers and follows the evolution of the manufacturing sector (Kozlowska, 2020; Zebardast et al., 2014). Servitisation is adopted by manufacturing

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organisations for many economic, strategic and environmental reasons (Buics & Eisingerné Balassa, 2020). These include competition from low-cost producers in developing countries and lacklustre domestic demand, given that products in these sectors are often oversupplied (Kozłowska, 2020). This situation creates a demand for advanced servitisation strategies to differentiate and maintain customer loyalty (Nguyen et al., 2022). However, previous studies also show that creating an appropriate environment is very important to servitisation adoption (Baines & Lightfoot, 2014; Liu et al., 2022). As such, the requirement for contextual alignment has made the delivery of successful servitisation strategies more complex (Kaňovská & Vlčková, 2022).

Thanks to the high purchasing power of consumers and an attractive consumerist culture, the Gulf Cooperation Council (GCC) region is a promising market for many organisations and a lucrative ground for bringing new product ideas to life. The GCC market, formed in 1981 and comprising six Arab monarchies - Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates - is primarily based on oil revenues; however, it has expanded across sectors. Furthermore, this economic wealth has drawn different international companies to this large-scale, tax-free market (Elbanna et al., 2020). However, certain industries had to adapt their products to the needs of the local GCC market. As a case in point, large shopping malls cater to local residents and expatriates living and working in the region. While these respective regulations and practices continue to shape the management style of retail fashion in the region, demanding adjustments to be made concerning the culture and values of the area, at the same time, tremendous economic power due to petrodollar-based globalisation and becoming a part of the world economy has attracted Western investors from other major markets, resulting towards radical societal changes. Such changes have been further backed by regional politicians and social elites who champion the ideals of modernity and embrace Western-style life. This shift has favourably impacted the fashion sector, with numerous brands expanding their presence within and beyond the GCC (Semaan et al., 2019). However, the unique cultural, regulatory, and economic landscape of the GCC significantly influences business practices within the fashion sector. Understanding these elements, including consumer behaviour, regulatory changes, and cultural norms, will offer richer insights into the specific challenges and opportunities for servitisation, enabling fashion businesses to tailor their strategies more effectively to the regional context.

In the Middle East, Arab consumers reportedly spent USD 89 billion on fashion in 2023, with a projected compound annual growth rate of 7% from 2023 to 2027 (Business of Fashion Insights, 2023). The GCC markets alone accounted for USD 50 billion in annual fashion sales, highlighting the region's substantial economic impact. Notably, Saudi Arabia and the United Arab Emirates rank among the highest per capita expenditures globally, at approximately USD 500 and USD 1,600 per person, respectively (Amed et al., 2020). Several regional retail conglomerates underpin the success of the consumer fashion sector in Gulf countries. The GCC is one of the leading markets for high-end (luxury) fashion brands (Husain et al., 2022), especially in Saudi Arabia and the United Arab Emirates, where the high-end fashion market is proliferating (Ramadan & Nsouli, 2022). For instance, the Kuwaiti retailer Al Shaya has introduced over 90 brands to the region, including H&M and Boots. Similarly, Fawaz Al Hokair, operating in the KSA and the broader region, has brought numerous high-street brands, such as Zara, Bershka, Aldo, and La Senza. Other significant contributors include the Apparel Group and the Chalhoub Group (Awad, 2018). The internationalisation process from an international marketing perspective, as in the case of Zara, is not new (Lopez & Fan, 2009). However, with increased competition, customer preferences and needs continually evolve as they demand greater value, diversity, transparency, and immediate satisfaction (Al-Abdallah & Bataineh, 2018), highlighting the importance of servitisation in the study context.

Research on servitisation is often considered universally applicable across manufacturing sectors and operating environments (Kaňovská & Vlčková, 2022; Raddats et al., 2019), a perspective of crucial relevance to this study. Consequently, the servitisation strategy holds considerable promise for the fashion industry, as it caters to unique customers seeking quality service evidence in such markets. The adoption of servitisation strategy in the fashion sector is accelerating as a means to enhance quality, reduce costs, improve time efficiency, and promote better sustainability (Galera-Zarco & Campos, 2021); servitisation positively influences perceived quality and positively affects purchase intentions (Tosun & Tosun, 2023) leading to better economic performance as indicated by sales growth and profitability (Johansson et al., 2019). While servitisation has been examined across various industries, such as manufacturing

and technology sectors (Huang, 2022; Luo et al., 2023), a notable research gap remains concerning its application and effectiveness across different industries and countries (Pal, 2016), including regional markets like the GCC. Despite the critical role of the fashion sector in the GCC, research on servitisation strategies, especially within organisations that represent significant names in the GCC fashion industry, has been minimal. Studies, such as those by Mutwalli et al. (2015) on servitisation provision in the Saudi public hospital sector, Durugbo et al. (2021) on servitisation in supply chain management in the GCC, and Zahoor et al. (2023) on the concept of servitisation in SMEs in the UAE, are only examples found on servitisation in the GCC.

Moreover, according to Brunet et al. (2017), academic development and empirical testing are relatively rare in high-end fashion. Accordingly, this study aims to bridge this gap by empirically investigating the servitisation activities of regional firms in the dynamic business environments of the GCC fashion markets. Furthermore, this research responds to the call by Lee et al. (2021) for more precise research to capture the conceptual framework of servitisation. The proposed servitisation framework drafted by Baines and Lightfoot (2014) encompasses six dimensions: facilities and their locations, micro-vertical integration and supplier relationships, information and communication technologies, performance measurement and value demonstration, people deployment and their skills, and business processes and customer relationships. Furthermore, this study seeks to investigate not only the current level of servitisation in the GCC fashion industry but also to identify any obstacles that might impede or prevent fashion entities in the GCC from adopting servitisation practices.

This work contributes to the literature in the following three ways: first, regional focus: previous research has concentrated on servitisation in Western manufacturing (i.e., Baines & Lightfoot, 2014) or SMEs (i.e., Zahoor et al., 2023); the present study is the first to empirically study servitisation within a GCC fashion market, which is influenced by distinct cultural, regulatory and economic factors (e.g., visa regulations and consumerism of luxury). Second, sectoral novelty: distinct from broader servitisation scholarship (Raddats et al., 2019), the authors explore how issues in fashion (e.g., rapid turnover of Arabic-speaking staff and supplier mistrust in IP-sensitive collaboration) inhibit adoption. Finally, a managerial framework has been designed, tailored to Baines and Lightfoot's (2014) six servitisation aspects to fit the GCC context and to show how they interact with regional obstacles (e.g., micro-vertical integration is inhibited by hierarchical decision-making).

As GCC economies continue to grow, understanding the implications of servitisation in the fashion sector is vital for industry practitioners and policymakers alike, offering opportunities to enhance business practices, customer satisfaction, and overall economic growth in the region. Consequently, the study is guided by the following research questions:

RQ 1: What is the current level of servitisation in the GCC markets within the fashion sector?

RQ 2: What obstacles might hinder servitisation adoption for fashion agents in GCC markets?

Using the methodological strategy outlined by Yin (2018), this study presents an extended investigation into how strategy is implemented within particular organisational settings. Bedside drivers and barriers will be explored, and comparative analyses will assess how firms navigate the wide-ranging territories of servitisation in GCC, based on varying cultural, regulatory, and economic contexts within the region.

1. Literature review

1.1. Concept of servitisation

Servitisation is one of the fundamental phenomena that describes how organisations (particularly manufacturing industries) are transforming to cope with the global economy and gain a competitive edge (Turovets & Vishnevskiy, 2019). This strategy means complementing products with new service offerings and moving the competition from product price to customer value by providing complete solutions to better fulfil customer needs and at a lower cost (Raddats et al., 2019). The move to servitisation calls for manufacturers to have more than a production-oriented functional focus that responds to problems with more involvement in the business ecosystem (Słowik & Sierocka, 2023). Research on servitisation has started to encompass operational management and, more recently, a supply network perspective (Raddats et al., 2019).

Newer research investigates the servitisation process implemented in different sectors, even identifying what motivated organisations to pursue serviti-

sation (Kaňovská, 2020). These drivers include advanced service provision over cost competition to gain a competitive advantage, developing resilient revenue streams, and a more efficient and responsive fulfilment to customer and market needs, resulting in a higher satisfaction level (Aurich et al., 2010; Baines & Lightfoot, 2014; Zebardast et al., 2014; Pigosso & McAloone, 2016; Raddats et al., 2019; Hänninen et al., 2020; Kozlowska, 2020). Implementing servitisation requires practices and technologies unique to the industry's type, size, and nature. In light of this, the work by Baines and Lightfoot (2014) set out to assess contemporary practices and technologies among organisations known to have successfully adopted servitisation, along with their implications for success; from that, they identified six core dimensions necessary for effective implementation. The current servitisation strategies may be best assessed in terms of these dimensions: facilities and locations, micro-vertical integration and supplier relationships, information and communication technologies, performance measurement and value demonstration, people deployment and their skills, and business processes and customer relationships. Dimensions that are often used to explore and quantify the reality of this servitisation strategy in the literature (e.g., Baik et al., 2019; Jagstedt & Persson, 2019; Huang et al., 2020; Mola et al., 2020; Shen et al., 2023).

Existing research on servitisation is mainly underpinned by universalism, and its application universally across sectors is discussed in relevant research (Kaňovská & Vlčková, 2022; Lederer & Miric, 2016). Yet this research challenges that assumption, given that GCC fashion firms are confronted with cultural-regulatory barriers (e.g., visa restrictions on skilled labour or a mall typology as a norm). Supplier dynamics and tech adoption paradoxes are substantial barriers that must be examined. Therefore, this paper will apply such dimensions to define and measure servitisation in fashion from a GCC perspective, with each mentioned dimension elaborated below. By contextualising servitisation within the fashion sector of Gulf Cooperation Council nations, the aim is to make several contributions. The authors seek to extend existing theoretical frameworks by applying the dimensions Baines and Lightfoot (2014) established to a region characterised by high labour mobility and less rigid supplier hierarchies. In so doing, the authors hope to disrupt typical integration models. Additionally, barriers have been identified in this industry and locale that have not been documented in other contexts, such as manufacturing or healthcare. Issues, including high employee turnover rates and linguistic divides, represent challenges unique to this economic and social environment. Finally, an action-oriented solution has been tailored to Gulf firms.

1.2. Facilities and their locations

A significant element of delivering advanced services is how closely the manufacturer works with the customer. Such immediacy can be achieved by setting up maintenance or repair facilities or service centres near customers (Ryu et al., 2020). The importance of this practice for successful servitisation is highlighted by Baines and Lightfoot (2014), who argued that the presence at the customer site with trained manufacturer personnel offers rapid diagnostics and fault repair. In doing so, the manufacturer is better able to create and sustain deep, long-term relationships with their customers, supporting daily relations and operations, thereby enhancing customer trust and loyalty.

Moreover, according to Chen et al. (2014), manufacturers consider access to and insights into markets, products, and customs as strategic drivers influencing their location decisions. This knowledge enables an optimised global network of service centres that support the needs of customers and suppliers (Lica et al., 2021). The primary focus is on balancing efficiency, effectiveness, costs, and time (Macchion & Fornasiero, 2021). In the fashion sector, this dimension can be observed in nearby centres for fashion retailers that support the implementation of new systems and technologies and are qualified to train employees across various departments within a business unit.

1.3. Micro-vertical integration and supplier relationships

Production is the key component of vertical integration and an essential strategy for manufacturers to control the processes, innovate better, and improve economic performance (Wadeson, 2017). Backwards and forward integration in an industry (Baines & Lightfoot, 2014) - where an organisation extends its operations into areas previously managed by upstream suppliers (backward integration) and downstream customers (forward integration) - enables it to cover more steps in the production and distribution value chain. The extent of vertical integration

can vary across manufacturers due to inherent industry differences, such as product lifecycle duration, economies of scale, technological advancement, and market imperfections (Huang & Liu, 2014). For serviced manufacturers, micro-vertical integration necessitates an extended presence to seamlessly integrate with business units in both the upstream and downstream directions (Hänninen et al., 2019). Furthermore, supplier relationship management is essential for manufacturing companies in the current dynamic and competitive marketplace. As with any relationship management, the buyer-supplier relationship is influenced by satisfaction's affective and cognitive dimensions (Wu et al., 2023). It enables an efficient and sustainable supply chain with frequent, reliable deliveries (Al Haj Eid & Al-Abdallah, 2024). However, for purchasing and supplying entities to effectively enjoy this kind of relationship and in the long term, they should offer mutual benefits, which highlights the desirability of collaboration between both manufacturers and suppliers at the strategic level (Alabdallah et al., 2014; Haq et al., 2023). This planned approach goes beyond fulfilling the operational requirements of the manufacturer and builds resilience in the complete supply chain, helping to achieve success for the entire servitisation strategy. Such integration is evident in the clothing industry and is one of the main foundations of a successful bond between manufacturers and retailers.

1.4. Information and communication technologies

Information technology (IT), or, more broadly, information and communications technology (ICT), is at the heart of nearly every modern manufacturing and service-delivery system. These technologies enable organisations to combine various hardware and software elements into a single system. This type of connectedness enables efficient connections between suppliers, partners and consumers within a country and across borders (Wendt et al., 2021). ICT tools play a vital role in distributing value-added services, thereby overcoming the shortfalls of manufacturing capabilities against customer requirements, such as order processing, delivery, maintenance and repair, and field operations; they are also useful for product design improvements.

Zhang et al. (2023) examined the relationships among servitisation strategies - product-related services and customer-oriented services - and two distinct types of inter-organisational IT capabilities. Their research suggests that services focused on the product should be matched with IT reconfiguration, while services oriented towards the buyer should be matched with IT integration to maximise performance. On the contrary, misalignment (product-centred services use IT to balance personal/business interests and customer-centred services use IT to reconfigure techs) would be detrimental to work culture and performance (Bataineh et al., 2016). This finding fills the knowledge gap between servitisation and IT capabilities, indicating that while IT can help achieve more operational efficacy and service efficiencies and contribute to environmental sustainability, it should be analysed from a strategic viewpoint where they are both aligned strategically to gain a competitive advantage. From this perspective, ICTs are no longer operational facilitators but strategic resources that can significantly impact servitisation strategies and their associated outcomes. Specifically, the use of data analytics allows firms to track effectiveness and inform future strategies (Al Adwan et al., 2023). ICT and IT systems play an essential role in ensuring a smooth flow of information between operations; besides helping with order processing and logistics backup, they are also imperative functions in fashion.

1.5. Performance measurements and value demonstration

Organisations spend considerable time assessing their performance in isolation and as part of the chain - setting targets, building plans, and declaring key performance indicators to scrutinise performance data. Such detailed examination facilitates informed decision-making (Aboumoghli & Al-Abdallah, 2018). In manufacturing, organisations adjust their performance measurement systems to mirror their customers, i.e., focusing on cost, speed, quality, quantity, or delivery, thereby ensuring value (Pasha & Poister 2017). This involves adopting a customer-centric approach that prioritises outcomes aligned with individual customer needs and processes (Zhao & Wang, 2021). Consequently, the service delivery systems employed by manufacturers may vary significantly to accommodate diverse customer requirements, yet all aim to demonstrate the manufacturer's inherent value (Baines & Lightfoot, 2014). Essentially, customer expectations directly influence performance metrics, which are then translated into micro-

measures by the manufacturer. These micro-measures relate directly to product and/or service performance and are further broken down into localised performance indicators. Such indicators highlight the value offered by reducing costs, enhancing flexibility, eliminating waste, and removing non-value-adding activities. This strategic focus ensures that all aspects of product and service delivery are streamlined to maximise value for both the manufacturer and the customer (Cantini et al., 2021). In addition to the above, the fashion sector performance measurement can be assessed through sales, marketing and branding, value creation and customer satisfaction.

1.6. People deployment and their skills

The servitisation strategy necessitates an innovative approach to the organisation, training, and enhancing employee skills to ensure they possess the appropriate behaviours for effectively delivering advanced services (Lim & Kim, 2018). Baines et al. (2013) identified six critical skill sets that underpin the desired behaviours of personnel involved in delivering advanced services. These competencies include: flexibility, which is the ability to adapt to different working conditions to meet customer needs; relationship building - developing a supportive and collaborative culture that extends from the internal operations of the manufacturer to its customer-facing functions; service-centricity - actively listening to and valuing clients' concerns and responding with emotional cues, empathy, and a commitment to problem resolution; authenticity - ensuring that commitments are realistic and within the capabilities of the manufacturer's values and promises; problem solving - analytical thinking and creative solutions to fulfil and exceed customer expectations; resilience - the ability to remain composed under pressure and to manage difficult situations effectively, which is necessary for handling customer complaints and dissatisfaction with calmness and reassurance. Acknowledging and incorporating these skills into the servitisation process improves service delivery and positively impacts customer satisfaction and loyalty (Nguyen et al., 2022; Al-Abdallah et al., 2023), as effective employee management is directly correlated with enhanced organizational performance (Jahmani et al., 2023). This comprehensive approach to employee development underscores the critical role of human factors in successfully implementing servitisation strategies, especially in the fashion sector, which is considered a provider of high-involvement products for most customers.

1.7. Business processes and customer relationships

Business processes are the intrinsic components of an organisation that synergise information, personnel, and facilities to organise and execute activities and tasks collectively, ultimately delivering a service or product to a customer (Brajer-Marczak, 2016). In the context of advanced services, processes are designed to yield desired outcomes from products, emphasising communication over negotiation to meet customer performance expectations (Singh et al., 2021). Baines and Lightfoot (2014) characterised such relationships as "touch-points", where the manufacturer aligns processes with the customer's extensive range of touch-points, facilitating the development of robust inter-organisational relationships. The servitised manufacturer must establish a communication framework that promotes information flow and facilitates employee interaction within and outside the organisation (Leon et al., 2020). Such communication and interactions among staff are crucial for refining business processes in the fashion sector, where all retailers are considered actual touchpoints with customers.

Consequently, these six dimensions are the driving forces behind delivering state-of-the-art services in the fashion retail sector and require deep consideration and strategic actions that may involve several stakeholders to strategise around. Furthermore, the interdependence between these factors clearly demonstrates that one can significantly affect another through inefficiencies (as mentioned in the two or more dimensions discussed). This analysis provided further evidence that servitisation strategies should be approached holistically and integrated to deliver meaningful, synergistic results.

2. Research methods

This research utilises an exploratory qualitative design to explore the adoption of servitisation strategies in the GCC fashion industry. In light of the emergence of servitisation research in this particular regional and sectoral context, a qualitative approach would be most suited to capture the subtle, complex barriers and practices from the grounded perspective

of senior industry leaders (Yin, 2018; Hennink et al., 2020). The methodology was designed to ensure depth of understanding and methodological rigour, in terms of including semi-structured interviews of purposively sampled participants and a detailed thematic analysis.

2.1. Semi-structured interviews

Semi-structured interviews conducted over three months were used to gather primary data. The interview guide consisted of 12 purposefully designed questions, ranging from general knowledge of servitisation to implementation issues. Aspects of data collection included the following:

Interview mode: face-to-face (n=6) and virtual (n=3) interviews.

Duration per interview: 45-60 minutes.

Recording and transcription: all interviews were audiotaped with consent and transcribed verbatim.

Ethical considerations: strong anonymisation rules, organisations and the affiliates provided with pseudonymous names.

This semi-structured approach balanced maintaining consistency across interviews and providing flexibility to discuss the development of emerging themes, including region-specific barriers to servitisation adoption.

2.2. Research population and sample

The design of the study was based on a detailed analysis of three multinational fashion companies (A, B, and C) operating in the six countries forming the GCC. The organisations were chosen using three key criteria, presenting the validity and the generalisability of the findings:

Market power: collectively comprising about 30% of the GCC fashion market (Chalhoub Group, 2022).

Operational network: continually retailing in all GCC countries (UAE, Saudi Arabia, Qatar, Kuwait, Oman, and Bahrain).

Balance of diversification: serving various market segments (luxury, high street, and hybrid businesses).

The purposive sampling strategy was focused on senior-level managers (n=9) who satisfied strict eligibility requirements, including at least five years of experience in the GCC fashion industry and direct engagement in managing a minimum of two servitisation dimensions according to the description by Baines and Lightfoot (2014). The sampling method guarantees respondents have the required knowledge and authority within their organisation to ensure insightful comments regarding practices and challenges of servitisation implementation.

2.3. Data analysis approach

A formalised six-stage process of thematic analysis (Braun & Clarke, 2006) was systematically undertaken on the interview transcripts. Stage one involved familiarisation, i.e., the repeated reading of transcripts to identify initial pattern codes. Next, an early coding followed, in which the codebook was generated using the NVivo 12 program. Then, similar codes were aggregated into general themes during theme generation. The themes were subsequently validated through peer debriefing (kappa = 0.81). The essence of the themes was then explicitly described in the theme definition process. The last phase of report production involved decisions about which illustrative quotes, if any, to use and the final analysis. For

Tab. 1. Description of the analysed retail fashion companies

Company	Years of operation	Size	Number of stores	Managerial positions of the interviewed personnel	Number of employees	Annual sales turnover, USD	Number of fashion brands
(A)	60 Years	Large	60 Stores distributed over Qatar, UAE, Oman, and Saudi Arabia	General Manager, Operations Manager and Store Manager	600 employees	20,000,000	100 fashion brands
(B)	40 Years	Large	200 Stores distributed over all six Arab Gulf countries	Operations Manager, Retail Manager and Store Manager	1500 employees	50,000,000	150 fashion brands
(C)	50 Years	Large	100 Stores distributed over all the Arab Gulf countries except Saudi Arabia	Director Manager, General Manager and Retail Manager	1000 employees	30,000,000	120 fashion brands

instance, within the theme "Regulatory Constraints", codes included visa barriers and localisation laws, from which one informant explained, "We can't get Arabic-speaking staff in many markets because of the visa restrictions, so that has been a consistent challenge that we have faced" (OM, B). Likewise, the theme "Supplier Relationships" cited codes, e.g., data-sharing reluctance and IP concerns, as in the quote "Full sales data is never shared with brand partners" (MD, A).

The research included several measures to establish the trustworthiness of the findings (Lincoln & Guba, 1985). Credibility was addressed through member checking with three participants to verify interpretations. Transferability was improved by describing the GCC context in detail, thereby facilitating future comparisons. Finally, confirmability was enhanced by retaining research reflexivity memos to counteract biases.

3. Research results

3.1. Compared dimensions of the servitisation strategy

In this study, a simple coding system was utilised to designate various dimensions of servitisation, using natural numbers to denote them and elucidate their roles in supporting the strategy. Dimension 1 (D1), localised facilities, delivers effective and efficient training that ensures a thorough and sustained understanding of product use and functionality. D1 closes the training capacity gap by providing a training facility [2]. Such facilities also aid in the digitalisation of knowledge relevant to distance monitoring, enabling manufacturers to perfect and adapt product designs or features conforming to market preferences (Bainest & Lightfoot, 2014). D2, micro-vertical integration and supplier relationships, reinforces production control, stimulates innovations, and improves supply chain performance. This integration links an organisation with its suppliers and customers to facilitate the delivery of enhanced services (Wadeson, 2017), where strategic flexibility and effective decision-making are essential for optimizing logistics performance (Abu Hamour et al., 2023). D3, information and communication technologies, allows firms to integrate IT systems that connect suppliers, partners, and customers worldwide. Timeliness is necessary for delivering effective information for business management, production planning, process control, facility management, and practical information sharing (Wendt et al., 2021). However, D4, performance measurement and value demonstration, is a crucial step in spreading advanced services by illustrating graphical performance measures for every single customer, i.e., every distributed market, by combining tools in the practical sense of one-to-many messaging. Key performance indicators, including cost, speed, quality, quantity, and delivery, are customised to meet the unique needs of each customer and enhance service value (Baines & Lightfoot, 2014). D5, people deployment and their skills, is indispensable for the servitisation strategy. Despite technological advancements, organisations invest in human capital, recognising its pivotal role in efficient operations. Thus, efforts are made to improve staff organisation, training, and skills to ensure they are equipped to deliver advanced services, as Baines et al. (2013) identified, especially for front-office employees. Finally, D6, business processes and customer relationships, is crucial for servitisation. Business operations must be inspired and determined by customer touch-points, reinforcing inter-organisational relationships where effective knowledge management is essential to sustain and improve these relationships amidst market changes and evolving customer expectations, as indicated by Brajer-Marczak (2016).

3.2. Interview results for Organisation A

Upon the completion of the interview with Organisation A, Table 2 below has been meticulously crafted to illustrate the results of the six dimensions mentioned above and their respective levels of usage or adoption, providing an overview of Organisation A's position in the servitisation strategy.

In general, the managers interviewed in Organisation A acknowledged a weakness within the front team, noting instances where sales personnel struggled to provide adequate responses regarding basic product knowledge. However, the ICT deployment has positively impacted the planning and development of business processes, particularly regarding speed, accuracy, and reliability. Information stored about product characteristics, such as materials, styles, colours, and sizes, is categorised and sub-categorised, enabling partners to better understand customer needs and preferences, as explained by the Managing Director (MD). Additionally, the use of business software plays a crucial role in providing partners with timely and accessible information for use in product production decisions.

Tab. 2. Servitisation dimensions and barriers in Company A

Servitisation dimension (Baines & Lightfoot, 2014)	Implementation level	Key barriers identified
1. Facilities & locations	Partial adoption	High real estate costs; cultural preference for mall-based retail
2. Micro-vertical integration & supplier relationships	Low adoption	Supplier distrust; IP protection concerns; hierarchical decision-making
3. Information & communication technologies (ICT)	Moderate adoption	Outdated systems; resistance to cloud-based platforms
4. Performance measurement & value demonstration	Emerging	Lack of standardised metrics; short-term profit focus
5. People deployment & skills	Critical weakness	Visa restrictions; high turnover; language barriers; inadequate training
6. Business processes & customer relationships	Moderate	Siloed departments; lack of employee empowerment

Partial adoption - some elements of the dimension are implemented, but not fully integrated or optimised.

Low adoption - the dimension is in the early stages of implementation with limited application across the organisation.

Moderate adoption - the dimension is implemented to a certain extent, with ongoing development and refinement.

Emerging - the dimension is beginning to be recognised and implemented, but is still in early phases.

Critical weakness - the dimension is significantly lacking and requires substantial improvement.

Moderate - the dimension is implemented to a certain extent, with ongoing development and refinement.

3.3. Interview results for Organisation B

Upon the completion of the interview with Organisation B, Table 3 below has been meticulously crafted to illustrate the results of the six dimensions mentioned earlier and their respective levels of usage or adoption, providing an overview of Organisation B's position in the servitisation strategy.

Similarly, Organisation B faces challenges with its front team and the limited deployment of micro-vertical integration. Integration with suppliers primarily focuses on operational cooperation, such as reporting sales movement by category and department. However, sharing other crucial information, such as customer orientation and preferences, is limited due to its sensitivity. On a positive note, the sales team has highly sophisticated and technologically advanced mobile devices. These devices are connected to both the local inventory and an online store, allowing them to check the availability of sizes and colours of items for clients, even if they are not in the local warehouse. Furthermore, deploying customer relationship management (CRM) systems on these mobile devices helps the firm manage customer interactions and efficiently collect their preferences.

Tab. 3. Servitisation dimensions and barriers in Company B

Servitisation dimension (Baines & Lightfoot, 2014)	Implementation level	Key barriers identified
1. Facilities & locations	Partial adoption	High real estate costs; cultural preference for mall-based retail
2. Micro-vertical integration & supplier relationships	Low adoption	Supplier distrust; IP protection concerns; hierarchical decision-making
3. Information & communication technologies (ICT)	Moderate adoption	Outdated systems; resistance to cloud-based platforms
4. Performance measurement & value demonstration	Emerging	Lack of standardised metrics; short-term profit focus
5. People deployment & skills	Critical weakness	Visa restrictions; high turnover; language barriers; inadequate training
6. Business processes & customer relationships	Moderate	Siloed departments; lack of employee empowerment

Tab. 4. Servitisation dimensions and barriers in Company C

Servitisation dimension (Baines & Lightfoot, 2014)	Implementation level	Key barriers identified
1. Facilities & locations	Partial adoption	High real estate costs; cultural preference for mall-based retail
2. Micro-vertical integration & supplier relationships	Low adoption	Supplier distrust; IP protection concerns; hierarchical decision-making
3. Information & communication technologies (ICT)	Moderate adoption	Outdated systems; resistance to cloud-based platforms
4. Performance measurement & value demonstration	Emerging	Lack of standardised metrics; short-term profit focus
5. People deployment & skills	Critical weakness	Visa restrictions; high turnover; language barriers; inadequate training
6. Business processes & customer relationships	Moderate	Siloed departments; lack of employee empowerment

3.4. Interview results for Organisation C

Upon the completion of the interview with Organisation C, Table 4 below was meticulously crafted to illustrate the results of the six dimensions mentioned earlier and their respective levels of usage or adoption, providing an overview of Organisation C's position in the servitisation strategy.

The third organisation made significant investments in employee development through training programmes, focusing on product knowledge and sales skills. As a result, the sales team in Organisation C can accurately and persuasively present and describe fashion products, enabling them to deliver advanced services effectively. However, due to cost-cutting measures, Organisation C operates with software and hardware purchased in 2015. Consequently, this outdated technology has detrimentally impacted the delivery of advanced services.

4. Discussion of the results

In addressing the concept of the servitisation strategy and its business implications, the MD of Organisation A elucidated the organisation's profound comprehension of the term and its potential merits:

"We acknowledge the term theoretically and practically and are actively implementing such a strategy in our current services. We also endeavour to integrate it with our present and future strategies."

Correspondingly, within organisation B, the Operations Manager (OM) underscored their extensive five-year engagement with the servitisation strategy, affirming that:

"We have found the servitisation strategy to be highly fitting for our operations and the GCC market, where most customers are under 30, each with distinct expectations and demands from older generations".

Meanwhile, in Organisation C, the General Manager (GM) provided a succinct interpretation of "servitisation" as:

"The provision of goods and services to our clients in the GCC market while continually adding value, including personalised services".

In terms of the competencies deployed, encompassing practices and technologies utilised in implementing the servitisation strategy, Organisation A's MD, OM, and the Retail Manager (RM) affirmed the substantial support from their partners. They mainly highlighted initiatives to enhance services and expand market share in the Gulf region. Utilising contemporary technologies, they gather and store data on fashion product characteristics, which is instrumental in developing new products. The OM acknowledges that:

"Although we had numerous policy schemes in place before officially adopting this approach, we promptly recognized the need for significant changes in our policies, strategies, and business operations in the GCC area".

Organisation B has embraced various initiatives to meet market demands and enhance services. They have also adjusted their approach with partners regarding relationship dynamics, information sharing, and timing. Despite initial resistance from some senior managers, communication levels with partners have been enhanced. In Organisation C, the OM asserted that:

"The primary driver of servitisation is the continuous enhancement of our goods and services to surpass our clients' expectations. We rely on advanced technology in our services for our customers, includ-

ing systems, and emphasise product and service innovation".

In addressing the challenges related to building the necessary ongoing relationship with suppliers/partners for servitisation, encompassing communication, coordination, and data sharing, the RM of Organisation A confirmed that suppliers are not granted access to the ERP database. Instead, reports are manually prepared using an ERP system to safeguard what the organisation deems confidential data, which may include retail prices or sales movement features.

Similarly, in Organisation B, the OM elucidated that sharing reports containing figures, such as sales movement and sell-through, necessitates approval from top executives. Such reports are considered sensitive as they reflect the organisation's image and performance in the eyes of its partners. The OM elaborated that:

"We do not typically disclose the total sales amount, but the information provided enables partners to estimate it, facilitating the implementation process of the servitisation strategy".

In contrast, in Organisation C, the OM emphasised that information sharing is pivotal in shaping their plans, making decisions, and staying ahead of the market's needs and requirements to deliver the advanced services they aspire to provide. However, the GM must confirm all reports and data records before disseminating them to their partners.

In addressing the challenges encountered during the implementation of the servitisation strategy, the three managers at Organisation A acknowledged the difficulties in recruiting and hiring the sales team in the Gulf region. They noted that most newly employed personnel lack experience and skills, requiring extensive training in almost every aspect of their jobs, particularly in providing customer services and solutions. The managers highlighted that all fashion companies in the Gulf region face significant challenges in finding suitable candidates in the sales market due to the local government's policies in the Arabian Peninsula, particularly regarding the issuance of new visas or the approval of transfer working visas from one sponsorship to another, influenced by political and/or economic reasons. The OM further confirmed the challenges in the recruitment process, stressing that it is a common struggle for all fashion companies to find native Arabic speakers with the necessary sales skills to serve and communicate with customers effectively, in addition to the high turnover rates for local employees:

"We have a complicated law for visa acquisition in most of the GCC countries, which prevents us from bringing employees from certain countries."

In the same vein, in Organisation B, OM identified the same two main challenges in the operational processes, which hinder the full adoption of the servitisation strategy. Compliance with the rules and regulations of the GCC region concerning labour law and difficulties in attracting Arabic-speaking employees in the market. The OM stated that:

"With the beginning of the so-called Arab Spring in 2011, the GCC countries have set several restrictions on bringing employees to the fashion retail market and other sectors from neighbouring Arab countries… The locals do not last long in such jobs as they view them as merely a temporary stage until they find something more relevant to their career path".

In Organisation C, managers underscored the challenges posed by the operational environment of the GCC region. They also emphasised the impact of visa laws on hiring and recruiting employees within Gulf nations, especially since most local employees are mainly college students or fresh graduates with no real intention to stay for long. Furthermore, the Store Manager (SM) highlighted another significant challenge related to the high cost of updating software and hardware technology. This challenge arises due to the region's limited availability of skilled IT companies. The SM emphasised that:

"One of the main challenges we face in implementing the servitisation strategy is the costly, constant requirement of updates in the services and technology systems that causes delays in preparing the goods to be displayed in our fashion store in time".

As for exploring the implications of the servitisation strategy on the value of goods and services, alongside the roles played by their partners in enhancing this value and the technologies needed for that, a range of perspectives emerged from different companies.

The MD at Organisation A noted that, through advanced technologies today, one can find and store the data on goods regarding their (a) type, (b) style, (c) material, (d) colour, (e) size, etc. And the organisation will lead to high value in goods and services.

On the flip side, with Organisation B, the SM mentioned that deploying and integrating CRM systems with business processes is key in delivering value to customers. With the help of a CRM system, an organisation can provide personalised services by

Tab. 5. Alignment of findings with servitisation dimensions

Servitisation dimension (Baines & Lightfoot, 2014)	Implementation status in GCC	Key barriers identified	Supporting evidence	Affected organisations
1. Facilities & locations	Partial adoption (local training centres but limited repair/return infrastructure)	High real estate costs; cultural preference for mall-based retail	*"We train staff in-store but lack dedicated service hubs"* (MD, B)	A, B, C
2. Micro-vertical integration & supplier relationships	Low adoption (operational coordination only)	Supplier distrust; IP protection concerns; hierarchical decision-making	*"Sales data is shared only after board approval"* (OM, A)	A, B
3. Information & communication technologies (ICT)	Moderate adoption (basic CRM/ERP)	Outdated systems (Org C); resistance to cloud-based platforms	"Our 2015 software can't handle real-time inventory checks" (SM, C)	C (severe), A, B (partial)
4. Performance measurement & value demonstration	Emerging (customised KPIs but no long-term tracking)	Lack of standardised metrics; short-term profit focus	*"We measure monthly sales but not customer lifecycle value"* (RM, B)	B, C
5. People deployment & skills	Critical weakness	Visa restrictions; high turnover; language barriers; inadequate training	*"Locals leave for government jobs within months"* (GM, C)	All (severely)
6. Business processes & customer relationships	Moderate (personalisation attempts but inconsistent)	Siloed departments; lack of employee empowerment	*"Store staff can't approve returns without HQ approval"* (OM, A)	A, C

giving attention to individual client needs or preferences, which improves their experience.

The OM from Organisation C highlighted the need for healthy relationships with partners, enabling flexibility in inventing, designing, and producing products, particularly in relation to Gulf market products.

Based on the mix of challenges in the interview data compared to those worked based on six dimensions and visual observations, most challenges these organisations face are driven by the outside world, which is also connected with challenges in the GCC operational environment. Conversely, internal challenges appear more amenable to resolution by adapting or adopting alternative practices and strategies. Moreover, the results indicate that while the three fashion retail organisations have embraced practices and technologies crucial for servitisation, their implementation often deviates from ideal methodologies. As digital technologies continue to advance, the role of digital transformation in enabling servitisation becomes increasingly pivotal through adopting technologies, such as artificial intelligence (AI), blockchain, and the Internet of Things (IoT), which are not leveraged by the GCC fashion sector.

These findings underscore two primary weaknesses impeding the servitisation efforts of these organisations. First, as elucidated across the three examined cases, transparency is insufficient and engagement with partners is limited (the fashion goods providers). This constrained relationship is influenced by factors such as competition over brand acquisition, apprehensions regarding sensitive data disclosure, and constraints on partner involvement in operations and hierarchical decision-making structures. Second, a notable challenge arises from the inadequately skilled front-line personnel due to neglected training programmes, the aftermath of the Arab Spring, language barriers, and prevailing visa regulations for foreign employees in GCC countries. These factors collectively hinder the effective implementation of the servitisation strategy.

Conclusions

Existing research on servitisation is primarily underpinned by universalism, and its application universally across sectors is discussed in relevant research (Lederer & Miric, 2016). Yet this research questions that assumption, given that GCC fashion firms are confronted with cultural-regulatory barriers (e.g., visa restrictions on skilled labour and a mall typology as a norm). Furthermore, luxury-specific supplier dynamics, such as competing intellectual property concerns, preclude sharing sales data (e.g., reports requiring board approval). Finally, tech adoption paradoxes should be mentioned, i.e., outdated inventory systems remain in place due to cost considerations, and despite the availability of advanced

CRM technologies (Table 4), this disconnect was not addressed in earlier frameworks (Table 3).

In response to the first research question (What is the current level of servitisation in the GCC markets within the fashion sector?), interview findings indicate that the servitisation strategy is in its nascent stages of implementation within the GCC fashion sector. While evidence exists for the foundational dimensions of servitisation, they are not integrated and operationalised as the literature recommends, yielding the desired outcomes.

In response to the second research question (What obstacles might hinder servitisation adoption for fashion agents in GCC markets?), several barriers impede fashion agents in the GCC markets from embracing servitisation on a broader scale. These barriers encompass a lack of product knowledge, insufficient attention to essential training programmes, scarcity of skilled employees, limited employee empowerment and involvement, language barriers, constraints on data sharing, and prevailing visa laws in GCC countries.

This research concludes that the six dimensions of servitisation outlined in previous studies are essential for successful implementation. Given their strong connections, adopting these measures will likely positively impact all aspects of the servitisation strategy. For international manufacturers and their partners in the GCC markets, getting this servitisation strategy off to a good start presents a long-term win-win opportunity for bringing high-end fashion goods to the market in much more innovative ways. On the other hand, the paper reveals many micro and macro-level aspects that affect the servitisation process in GCC. Related to the inadequate knowledge about the product, absence of necessary training programmes, lack of training personnel, investment control in the organisation, the language barrier between human resources and also availability and data sharing limits due to various extents of technology implemented and specifically visa laws available in the GCC Nations. Overcoming these challenges will be essential for fashion developers in the GCC to remove barriers and unlock the benefits of servitisation.

These research findings differ from those of earlier servitisation research in three main areas. First, unlike Zahoor et al.'s (2023) study on UAE SMEs, which identified ICT adoption as the principal source of servitisation, GCC haute couture organisations encounter conflicting tech barriers: despite deploying CRM systems (Table 3), antiquated stock management investments endure because of risk aversion (Table 4). This outlines the industry's focus on IP protection rather than operational agility. Second, while Raddats et al. (2019) presented supplier integration as a cross-industrial issue, GCC fashion organisations face the heart of hierarchical decision-making (e.g., board approvals to share the data, Section 4.1.2), which is a limitation that is embedded in regional business cultures. Third, in contrast with manufacturing research (Baines & Lightfoot, 2014), labour turnover in these settings reflects visa policies and competition with government jobs (Section 4.2), thus a place-specific labour strategy.

To summarise, this study has unearthed and examined the novel routes and extent of servitisation strategies in the GCC fashion markets. The study has provided insights into service-oriented practices in the fashion industry through assessing adoption and barriers to implementation. It has also addressed the literature gap in examining servitisation usage in a regional context and its performance (Huang, 2022; Luo et al., 2023; Li et al., 2021; Zahoor et al., 2023). By providing empirical proof of service behaviours undertaken by local firms, this research has furthered considerable understanding of how the business landscape is evolving in the GCC fashion markets and also through servitisation and its perception and implementation by businesses in this region. This means there is a slight improvement in the distant future's servitisation measurements, which this paper provides proper guidance towards (Lee et al., 2021) as a typical dummy variable treatment.

Managerial implications

This research indicates that fashion organisations in the GCC are proactively refining their operations and strategies to better align with the demands of servitisation. However, challenges stemming from the operational environment in the GCC region are hindering efforts to find and recruit employees possessing the necessary skills and knowledge. Nevertheless, the research identified several strategies for fashion firms to enhance their positioning towards servitisation. One such strategy involves implementing training programmes for their partners across various areas. These programmes impart the knowledge and skills needed to deliver advanced services.

Additionally, managers highlighted limitations on the data provided to their partners. While the specific data types withheld were not explicitly identi-

fied, the literature suggests that any constraints on data sharing and integration could impede the optimal outcomes of servitisation. Therefore, these organisations must foster transparent relationships with their partners, enabling them to assume more operational roles. Managers should empower their staff members, including store managers, supervisors, and front-line teams, to take on more active roles in servitisation. By doing so, they can leverage their workforce's collective expertise and insights to drive the successful implementation of servitisation strategies. Lastly, the analysis pinpoints two pressing areas of policy concern for GCC governments. The first is to adjust retailer visa quotas to help alleviate the shortage of Arabic-speaking talent (Section 4.2) and to modify visa laws that favour other industries (e.g., construction and health). Second, encouraging local IT upskilling initiatives would decrease dependency on expensive foreign tech solutions- one of the outdated systems mentioned in Table 4.

Addressing barriers: strategic advice

The results reveal three principal barriers affecting the acceptance of servitisation in GCC fashion companies: supplier mistrust, employee skills shortages, and antiquated ICT infrastructure. To mitigate these problems, interventions were outlined. In the context of supplier relationships, companies should establish a series of trust-based stages, starting with sharing aggregated sales trends and working towards collaborative demand forecasting and even real-time systems integration over secure platforms, e.g., blockchain. This sequential model enables partners to prove their trustworthiness while safeguarding sensitive IP. At the same time, it would be helpful for companies to set up cross-innovation teams with their most important suppliers to co-develop services, such as customised styling programmes or repair services.

A two-pronged skills development and retention solution has been proposed regarding human capital challenges. Fashion retailers should collaborate with local schools to develop training programmes for Arabic language focused on luxury product knowledge, service skills at an advanced level, and digital fluency. To control the high turnover, companies must remodel career pathways for local talent, with clear steps from entry-level positions to specialised ones, such as personal shoppers, and government incentives to train national workforces.

Modernising technology should be a commonsense, cost-effective approach. Companies should also focus on modular enhancements to their current systems, start with a cloud-based CRM deployment, and then add API connections to legacy inventory systems over time. Those of the GCC region can cooperate with technology vendors based in GCC countries to develop custom solutions, attuned to regional market nuances, and pilot testing Arabic-language AI assistants could provide evidence that the digital transformation needle can be moved without a gargantuan infrastructure overhaul. This incremental progress (within the sector's technological risk management comfort zone) is finding a happy medium between risk aversion and the urgency to foster competitiveness.

Implementation should be on a structured timetable with an initial audit of existing capabilities (0-6 months) and a pilot test of key initiatives (6-18 months), with eventual scale and performance monitoring via servitisation-specific KPIs, such as customer retention rates and service revenue contribution. This deliberate approach lets them course-correct while showing results and securing internal buy-in.

Limitations

One of the most critical limitations of qualitative studies is their contextual nature, where conclusions are often tailored to the specific environment and participants involved. This customisation can make it challenging to generalise the findings to a larger population. Therefore, the results and conclusions of this research study are constrained to the prominent fashion firms in the GCC market. Enhancing the generalisability of the results would require future research with a more extensive and more diverse sample. Furthermore, the lack of published studies on servitisation in the GCC's fashion sector underscores the importance of this research. This, however, also makes benchmarking these results against similar studies difficult.

Future research

This research can positively contribute to future studies investigating servitisation strategies, dimensions, effects and implementation processes specific to the GCC fashion market. The barriers identified in the firms are revealing for future research concerning

their underlying causes. Further empirical validation of these results in other cultural environments would help clarify how culture influences perceptions, behaviours and experiences relating to servitisation.

Since this study was exploratory and limited to multinational organisations operating in the GCC fashion sector, future research should more broadly sample industries or sectors. This research effort focused on various constituents in the fashion ecosystem, from SMEs to startups and other partners on the supply chain side and the point of entry to end customers. Increasing the sample size would also enable a mixed-method approach: quantitative methods, such as surveys, could corroborate and broaden qualitative findings. Further studies could also challenge more novel, technological-focused methods - as in digital servitisation - to explore technology as a potential mediator for servitisation strategies and innovation in the GCC fashion sector.

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In search of factors reinforcing the relationship between organisational resilience and organisational performance: a conceptual framework and research results

Anna Zabłocka-Kluczka

ABSTRACT

The study aims to explore how external support and the ability to understand systemic linkages (organisation's capability for systems thinking) influence the relationship between organisational resilience and organisational performance.

The empirical research was conducted to verify whether external support and systems thinking have the capacity to moderate the relationship between organisational resilience and organisational performance. A set of hypotheses was developed based on the theoretical research and subsequently tested on a sample of 268 organisations operating in Poland. Two alternative testing methods were used: stepwise regression analysis with a moderator and Hayes' PROCESS macro technique (also based on regression analysis). The Johnson-Neyman technique was used to identify regions within the range of the moderator variable, where the effect of the focal predictor on the outcome was statistically significant or non-significant.

The obtained results clearly show that the external support and systems thinking, when considered separately, act as moderators of the analysed relationship. The model with two moderators is also statistically significant, and the simultaneous inclusion of both moderators significantly increases the percentage of explained variance. However, an interesting phenomenon can be observed here. The analysis of conditional effects reveals that at a low level of systems thinking, and across all levels of external support, the moderation effect is not statistically significant. It becomes statistically significant only at the average and high levels of systems thinking, and at both of these levels, the effect increases with the rise in external support.

This study provides important insights into the factors influencing the relationship between organisational resilience and organisational performance. It emphasises the importance of systemic linkages and, above all, the understanding of the context in which organisations operate.

KEY WORDS

organisational resilience, organisational performance, external support, systems thinking, management

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Introduction

In a rapidly changing environment, organisations are increasingly facing disruptive events that threaten the continuity of their existence. Organisational resilience is thus becoming a key determinant of an organisation's ability to survive and thrive. This raises the question of whether it also affects organisational performance. Most research indicates a positive correlation between organisational resilience and organisational performance (Chowdhury et al., 2019; Suryaningtyas et al., 2019; Zahari et al., 2022; Raza & Anwar, 2025); however, it does not provide a clear

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answer as to whether resilience always and under all conditions translates into improved organisational performance. The dynamics of this relationship remain the subject of scientific debate, and the results of empirical studies are not always conclusive (Prayag et al., 2018; Schäffer, 2020). This suggests that various factors may influence the strength and direction of this relationship and highlights the need for a deeper understanding of its nature, considering the elements that affect its intensity. There are only a few studies in the literature analysing the role of mediators and moderators in the relationship between organisational resilience and organisational performance. For example, a study by Suryaningtyas et al. (2019) found that resilient leadership and organisational culture play an important mediating role in this relationship, while Wang et al. (2022) indicated that environmental dynamism serves as a moderating factor, enhancing the positive impact of organisational resilience on competitive advantage through organisational learning. Despite existing research, a comprehensive understanding of the factors influencing the evolving relationship between organisational resilience and organisational performance is still lacking. Despite growing interest in organisational resilience, a research gap remains regarding the contextual determinants that may enhance or undermine its impact on organisational performance. In particular, the role of different moderators (both external and internal) has been insufficiently explored.

Among external factors, one under-researched area is external support, which can be understood as institutional support (e.g., public policies, emergency assistance, and regulation) and inter-organisational relationships (including collaboration with partners, access to network resources or mutual support). In some contexts, these external support mechanisms may determine whether an organisation's resilience is more rapidly transformed into tangible outcomes (organisational performance) or not. A second potential moderator that has so far received insufficient research attention is an organisation's ability to understand systemic linkages in its environment (systems thinking). In times of complexity and discontinuity, responding effectively to change depends not only on the strength of internal resources, but also on an organisation's ability to perceive itself as part of a broader system, such as supply chains, innovation ecosystems or interdependence structures. Organisations capable of such systems thinking can more accurately anticipate the effects of change, make more integrated decisions and interact more effectively with others, also in the context of drawing on external support. Drawing on the aforementioned considerations, this study formulates the following research problem: how do external support mechanisms and systems thinking capabilities influence the relationship between organisational resilience and organisational performance? Therefore, this study aims to explore how external support and the ability to understand systemic linkages (systems thinking) influence the relationship between organisational resilience and organisational performance. To address the research objective, a quantitative approach was adopted. The empirical study was conducted to collect data that served as the basis for verifying the assumed relationships among the variables. The starting point of this study, however, is clarifying the concept of organisational resilience, which lies at the core of the research inquiry.

1. Literature review

1.1. Organisation's resilience and its measurement problems

Although organisational resilience is not a new concept and has evolved, there is still no consensus on its substance. The difficulty in defining it also stems from various ways in which the organisation's essence is conceptualised. Research papers on organisational resilience are rooted in a variety of theoretical frameworks, ranging from systems theory (Holling, 1973) or Complex Adaptive Systems (CAS) theory (Holland, 1992) to resource dependence theory (Pfeffer & Salancik, 1978) and High-Reliability Organisations (HRO) theory (Weick & Sutcliffe, 2001; Sutcliffe, 2011), to the currently prevailing approach grounded in the theory of dynamic organisational capabilities (Teece et al., 1997).

There is an ongoing debate on whether resilience resides in organisational structures or emerges through organisational actions, whether it is a skill, a certain attribute, a feature, a property of the organisation, or rather a set of abilities or capabilities that an organisation develops to cope with and in coping with unexpected events (Zabłocka-Kluczka, 2020). From the perspective of engineering and systems theory, resilience is defined as a single stable state to which the system can return after a perturbation, a capacity for robustness or the ability to recover critical functions and return to equilibrium following a disruptive event (Coutu, 2002; Horne & Orr, 1998; Kantur & Iseri-Say,

2015; Limnios et al., 2014; Riolli & Savicki, 2003). Organisations perceived as systems are resilient if they can quickly return to an acceptable state after disruptions, demonstrate the ability to withstand shocks, and bounce back after being bent (Madni & Jackson, 2009). According to Hollnagel (2014), resilience pertains more to the dynamic behaviour and adaptive performance of a system than to any fixed structural attribute. This way of thinking has shifted understanding of organisational resilience towards internal organisational reliability (Perrow 1984; Weick & Sutcliffe, 2001; Linnenluecke, 2017) and towards systems, mechanisms, and procedures that reduce the organisational volatility and enhance predictability under conditions of sudden threats (i.e., risk management). According to Powley (2009) and Ortiz-de-Mandojana and Bansal (2016), resilience is a latent dynamic capability, shaped over time by detecting and amending maladaptive tendencies, and tends to manifest only when the organisation confronts unexpected challenges. Thus, it is activated when an organisation faces a threat but is built much earlier, not only through systemic or structural solutions, but also through social interaction, relationships and organisational learning (Smith & Elliott, 2007; Sutcliffe & Vogus, 2003; Powley, 2009). The growing focus on the intangible dimensions, through which resilience is formed, has prompted a shift in research towards the theory of dynamic capabilities. This approach extends the understanding of resilience to include anticipatory sensing of threats, adaptive learning, and the ability to capitalise on adverse conditions (Hamel & Välikangas, 2003; Duchek, 2020; Duchek et al., 2020; Koronis & Ponis, 2018).

The complex nature of organisational resilience has led to the development of many methods for its measurement, which can be confusing given the multitude of factors being assessed. An overview of various approaches to measuring organisational resilience is provided by Rahi (2019), Chen et al. (2021), Hillman and Guenther (2021), and Ignatowicz et al. (2023). No perfect measurement framework emerges from these studies. Since many of them are context-specific, none can be considered universally better or worse. A good starting point for classifying methods of measuring organisational resilience appears to be their conceptual assumptions. The discourse remains open as to whether organisational resilience should be measured ex-post or ex-ante, and whether the metrics should be static or dynamic, quantitative (sometimes even purely financial) or qualitative and descriptive.

Measuring organisational resilience ex-post, as an outcome category, is consistent with the idea that resilience is understood as the ability to "bounce back" and is demonstrated only when the organisation is exposed to factors disrupting its functioning. Measures adopted in this approach usually describe speed or efficiency of return to baseline (and often this baseline is defined by the performance of an organisation). These measures are typically not very elaborate and are limited to one or a few metrics (dimensions), generally assessing the magnitude of disturbance the system can tolerate while still persisting, such as:

- recovery time (Gittel et al., 2006; Erol et al., 2010; DesJardine et al., 2019),
- severity of loss (DesJardine et al., 2019) or more precisely, a drop in performance (Ilseven & Puranam, 2021),
- rate of survival (Ortiz-de-Mandojana & Bansal, 2016), rate or level of recovery (Erol et al., 2010; Ilseven & Puranam, 2021), sometimes combined with
- level of vulnerability (Erol et al., 2010).

The main limitation of this measurement is that organisational resilience can only be considered retrospectively - it is impossible to measure and assess it before a crisis occurs. Such an approach makes it easy to compare the resilience of different organisations, even across various industries, but it seems to be of limited use for the management of an organisation in the context of a specific crisis. It must be admitted, however, that the knowledge gained during a given crisis can be successfully used to shape the future resilience of the organisation.

The limitations of the presented approach have become the impetus for the search for useful and reliable tools and techniques that allow for improving or shaping organisational resilience in advance, and at the very least provide organisations "with information on their resilience strengths and weaknesses before a crisis happens" (Lee et al., 2013, p. 30). These approaches focus on measuring factors, processes, elements, or dimensions that influence organisational resilience. In particular, they concentrate on elements that precede or constitute organisational resilience, or on the phases of the resilience-building process. One of the more popular models of resilience measurement that combines typical ex-post measures with an assessment of available resources is the 4R model of Bruneau et al. (2003). Although it is not specific to organisations, the authors proposed measures applicable to organisations within four performance criteria (robustness, redundancy, resourcefulness, and rapid-

ity). Equally popular is the Benchmark Resilience Tool (BRT), proposed and developed by Lee et al. (2013) and Whitman et al. (2013). It has evolved over time and is now a two-factor model, in which organisational resilience comprises two dimensions: planning and adaptive capacity. These are assessed using 13 indicators measured by 53 items, although researchers often use their own variations of the original three-dimensional scale, such as Roberston et al. (2022). A similar approach to assessing organisational resilience can also be found in ISO Standards 22316:2017, BS 65000:2014 or BS 65000:2022, which provide guidance for enhancing organisational resilience. From the perspective of the process approach, organisational resilience can be assessed by examining the processes (sub-processes) that contribute to its development. Following this logic, Ates and Bitici (2011) proposed a conceptual framework based on 29 management practices developed across five change process phases (preparing, planning, implementing, embedding, and reviewing). A different, yet still process-based, approach to measuring organisational resilience was adopted by Aleksić et al. (2013) and Macuzić et al. (2016). In both cases, a fuzzy set approach was applied. What comes to the fore here is not so much the identification of resilience factors (done within a specific industry context), but rather a holistic assessment of these factors and the comparison of their relative importance in contributing to organisational resilience. These frameworks provide more actionable information to decision-makers in shaping more resilient business strategies. However, such mathematical models of organisational resilience are constrained by one key limitation: the need for well-structured business processes and a carefully selected set of resilience attributes. A Fuzzy-Jess expert system for measuring business resiliency was also developed by Asgary et al. (2009). A process-based approach combined with the concept of dynamic capabilities can be seen in Duchek's (2020) three-dimensional proposal (in which organisational resilience consists of anticipation, coping and adaptation capabilities), conceptualised and operationalised by subsequent research, such as by Ahmić (2022). Finally, there are also frameworks grounded in the theory of dynamic capabilities, which lie at the heart of contemporary understandings of organisational resilience. Theoretical models by Sutcliffe and Vogus (2003) and Lengnick-Hall and Beck (2005), Lengnick-Hall (2011), which discuss cognitive, behavioural, and contextual or structural dimensions of resilience, have been operationalised by their successors. For example, Akgün and Keskin (2014) developed a measurement model consisting of 21 items across six areas (competence orientation, deep social capital, original/unscripted agility, practical habits, behavioural preparedness, and broad resource networks) derived from the proposition of Lengnick-Hall and Beck (2005).

According to Hillman and Guenther (2021), what is common to all these frameworks and measurement models is that resilience is understood and conceptualised as a latent, multidimensional higher-order construct. This is because it is a deep-rooted and intrinsic characteristic of the organisation that can never be fully discovered, but only evaluated with varying degrees of accuracy. An important issue is the variety of dimensions and attributes shaping organisational resilience that are considered in the proposed models. The large number of evaluation criteria and measures raises a problem from the perspective of the practical application of these methods.

To summarise, measuring organisational resilience is a challenging task. Different frameworks for measuring organisational resilience are usually strongly influenced by their conceptual anchors (entry points), do not provide a complete picture, and are only partially (if at all) comparable (Schipper & Langston, 2015). The use of a particular method should therefore be dictated by the purpose of the measurement. This paper focuses, among other things, on understanding systemic linkages, which justifies the choice of an approach rooted in systems theory resilience.

1.2. Organisation's resilience, external support, systems thinking, and organisational performance - hypotheses development

External support refers to both tangible and intangible resources that organisations receive from external stakeholders - such as partners, institutions, or public agencies - with the aim of strengthening their capacity to cope with challenges and pursue their goals (Spear, 2006). Cheah et al. (2019) discuss external support in terms of the type of support (direct and indirect) and the type of stakeholders (e.g., governmental or non-governmental). Support can also be considered through the prism of a unilateral relationship (as in the case of government assistance to organisations), or it can result from bilateral or multilateral ties created through a process of market cooperation (e.g., as a result of networking).

Support offered by the government is usually actional, situation-dependent, and aligned with current policy, typically aimed at absorbing disruption or maintaining economic or social order (Hereida et al., 2022; Taneo et al., 2022). It may include both direct and indirect forms of support. Direct support is usually targeted at specific types of organisations and includes financial (e.g., regulatory frameworks, tax reduction, subsidies, and loans) and operational (e.g., permissions and licenses) benefits that organisations can actively solicit from the government. Indirect support (e.g., policy interpretation, information sharing, infrastructure investments, law enforcement, or R&D prompting) is addressed to a broader range of firms or industries (Gao et al., 2022). Government support for building organisational resilience is not merely theoretical. Many countries, especially during the COVID-19 pandemic, established national programmes and initiatives to reinforce this stance. In Poland, for example, to mitigate the economic impact of the 2020 pandemic crisis, the government prepared and enacted an assistance package consisting of six Crisis Shields (1.0, 2.0, 3.0 for big enterprises, 4.0, 5.0 - the Tourism Shield, and 6.0 - the Industry Shield) and Financial Shield 1.0. (Dębkowska et al., 2021). While assessments of the effectiveness of such initiatives vary, the literature provides evidence that governmental support positively influences organisational resilience (Gao et al., 2022; Kim et al., 2021; Taneo et al., 2021).

According to Kim et al. (2021), organisational resilience is a network outcome. Organisations that are closer to each other tend to be more resilient; however, this does not necessarily mean that an organisation must play the role of a network broker or be in the centre of the network. By definition, a business network is an organisation's formal or informal arrangement that enables it to gain and exchange resources (Ahuja, 2000), which are crucial in overcoming the difficulties of crises. The literature provides evidence that, in the context of adversity, relational capabilities - the social connections that enable access to and exchange of resources - play an important role in shaping organisational resilience (Williams et al., 2017). Business networks are positively correlated with organisational resilience (Xie et al., 2022; Xie et al., 2025; Liu & Yin, 2020), and this appears to be true in the short term. However, research is lacking on how reliance on external assistance affects the long-term development of organisational resilience.

To summarise, it is difficult to disagree with the thesis of Ratnawati and Suryani (2024, p. 75) that "in encounter crises, business cannot stand alone". External support is thus important for organisational resilience (at least in the short term). Considering all the above, the following research hypothesis can be formulated:

H1: A positive relationship exists between external support and the organisation's resilience.

Organisations are, by definition, set up to operate in a competitive market environment. They strive not only to survive but also to gain an advantage over others in competing for limited resources, which, under the same conditions, determine their ability to achieve objectives. The mechanism of competition necessitates continuous improvement of products, processes, and management models. Market success - especially in the case of business organisations - is measured primarily by the ability to generate a sustainable financial surplus. In practice, however, the ability of organisations to participate in this "market game" varies greatly. Not all organisations have equal access to resources, knowledge, relationships, or institutional support. For many (especially those that are smaller, younger or operate in difficult sectors), functioning in a highly competitive environment presents significant barriers. In such cases, external support, both tangible (e.g., funding, infrastructure) and intangible (e.g., advice, regulatory facilitation), can play a crucial role not only in enabling them to remain viable but also in significantly increasing their competitiveness, regardless of the source from which this support originates.

According to Hereida et al. (2022), an organisation's success depends on access to government support, especially in the case of third-sector organisations. Government grants and donations positively influence financial efficiency (Ecer et al., 2016) and the achievement of an organisation's objectives (Thompson & Williams, 2014). Training support provided by the government also has a positive impact on business success, affecting both financial and non-financial performance, as well as organisational innovativeness (Rahman et al., 2015). Such assistance may also be significant for business organisations, but the support obtained through networking processes appears to be of even greater importance. According to Ahuja (2000), in this context, the position of an organisation within interorganisational networks matters for strengthening its outcomes. Moreover, network structure also plays an important role: both direct and indirect ties serve as sources of information, while direct ties additionally serve as sources of resources. Linkages and the resulting collaboration networks are key vehicles through which firms gain access to external knowledge (Fernandez-Perez et al., 2012). A num-

ber of benefits of participating in inter-organisational networks are cited in the literature, such as a sense of greater security, increased resource flexibility, reduced capital needs, risk transfer, knowledge sharing, enhanced innovation, and access to new customers. Although sometimes risks and negative aspects associated with interorganisational networks are also noted (Kawa & Pierański, 2015), the benefits of remaining in the network appear to outweigh the drawbacks. Therefore, the following research hypothesis is formulated:

H2: A positive relationship exists between external support and organisational performance.

Hereida et al. (2022) stated that organisations need to develop their resilience to foster future success and survive in complex environments. However, according to Legnick-Hall and Beck (2003), resilience is more than just bouncing back, and turning challenges into opportunities creates the conditions to perform better than before. This opens up the debate as to whether organisational resilience indeed implies improved performance.

The prevailing view in the literature is that organisational resilience promotes organisational performance (Sundström & Hollnagel, 2006; Carden et al., 2018; Chowdhury et al., 2019; Suryaningtyas et al., 2019; Beuren et al., 2021; Zahari et al., 2022; Raza & Anwar, 2025). However, both concepts are multidimensional and fuzzy, hence the question arises as to whether resilience always and under all conditions translates into improved organisational performance. As already noted, defining organisational resilience is challenging. Equally challenging is also defining organisational performance (Cheah et al., 2019). These two multidimensional constructs do not necessarily have a clear or direct relationship with each other. Schäffer (2020) noted that "organisational resilience hardly appears compatible with the mindset of short-term efficiency and performance maximisation that prevails in stock-listed and many other companies". Moreover, resource redundancy, which is one of the ways of building organisational resilience, results in very tangible short-term costs, which may detract from the overall organisational performance. Prayag et al. (2018) confirmed this thesis. Hollands et al. (2023) did not find support for the claim that variations in organisational resilience over time affect business success; however, their results indicate that more resilient organisations tend to enjoy greater business success overall. Therefore, the following hypothesis was formulated:

H3: A positive relationship exists between the organisation's resilience and organisational performance.

The relationship between organisational resilience and organisational performance is therefore not so automatic or straightforward as it may seem. An organisation may be resilient (i.e., able to survive a crisis) but not necessarily perform better. External support may thus determine whether, and to what extent, this resilience is successfully transformed into tangible results and whether the rebound from adversity leads to strengthened performance. Therefore, the following hypothesis may be formulated:

H3M1: The higher the external support, the stronger the influence of the organisation's resilience on the organisational performance. External support is a moderator for the relationship between the organisation's resilience and organisational performance.

Systems thinking has its origins in the assumptions of Ludwig von Bertalanffy's systems theory. According to this concept, an organisation can be understood as a system in which information and other resources are exchanged to achieve the organisation's goals. The individual parts of the system are closely interconnected, and even a small change within one of the smallest subsystems can have a significant long-term impact on the whole (Koźmiński et al., 2013). The cognitive competence of recognising and understanding these relationships is the essence of systems thinking. Systems thinking is the ability to consciously consider objects and phenomena in the surrounding world as systems in their development and interdependence to analyse problem situations, to identify the contradictions that have created them, and to find the most effective solutions to the problems that have arisen (Petrov after Humenna, 2024). Skaržauskienė (2010, p. 50) stated that "an effect of systems thinking is relevant in the modern world, which generates more information than it is possible to control and creates interrelations that are difficult to forecast". In this context, managers today need not only the skills to make decisions, solve problems, and act in an unstable environment, but also the ability to understand the causes and consequences of their decisions. Understanding these interrelations requires systems thinking.

In light of the Resource Dependence Theory (RDT), organisations are open systems constrained by their environment in terms of access to resources (Pfeffer & Salancik, 2015). According to Cheah et al.

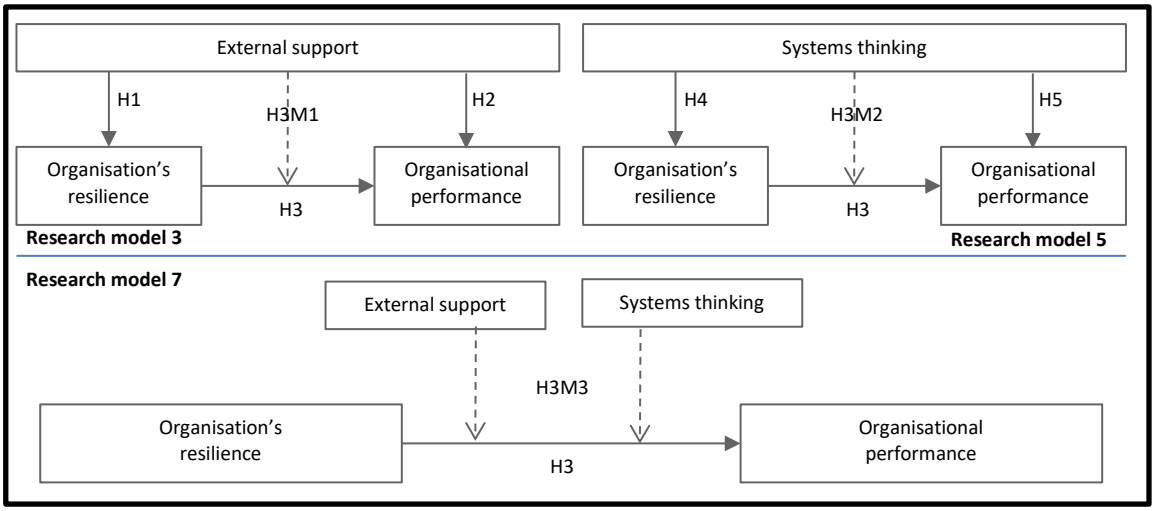

Fig. 1. External support and systems thinking as moderators of the relationship between the organisation's resilience and organisational performance.

(2019), an organisation's survival is limited by the availability of resources, which is shaped primarily by its ability to acquire external resources. This, in turn, requires an understanding of the interrelationships and context in which the organisation operates. The starting point for understanding the environmental linkages is the organisation's ability to be fully aware of its surroundings and their changes (commonly referred to as sensemaking (Weick, 2011) or situation awareness (Lee et al., 2013)). Systems thinking, although most often referred to as the analysis of an organisation's relationship with its external environment, is also crucial for understanding its internal dynamics. The ability to respond to unforeseen incidents and crises derives primarily from the ability to adapt, maintain business continuity, and recover from disruptions (Hamel & Välikangas, 2003; Duchek, 2020; Duchek et al., 2020; Koronis & Ponis, 2018). These processes largely depend on the internal structures and mechanisms that shape the organisation's functioning. Systems thinking enables a better understanding of the interdependencies between the organisational elements, processes, and resources; it promotes coordination and coherence of activities and facilitates faster decision-making. Therefore, the following hypothesis can be formulated:

H4: A positive relationship exists between systems thinking and the organisation's resilience.

As the drivers of an organisation's resilience are in many cases the same as those that are needed to gain a competitive advantage (Mitroff & Pauchant, 1989), one can also assume a link between systems thinking and organisational performance. According to Boyatzis and Goleman (2007), systems thinking is a cognitive intelligence competence, an ability to think or analyse information or situations that leads to effective or superior performance. For Senge (2000), it is the key (the titular "fifth") discipline enabling organisational learning. Surprisingly, although it is considered a valuable and desirable managerial competence, there is little empirical research verifying how much and to what extent it translates into organisational performance. One of the few examples is the paper of Skaržauskienė (2010), which demonstrated that organisational performance could be explained by systems thinking competencies (such as process orientation, interactivity, systems logic, dynamic thinking, etc.). In light of the above, the following research hypothesis is formulated:

H5: A positive relationship exists between systems thinking and organisational performance.

As with external support, understanding system linkages also appears to have the potential to influence the strength of the relationship between organisational resilience and organisational performance. An organisation's ability to see itself as part of a larger system of economic and institutional linkages, as well as its ability to understand how the interaction of internal elements contributes to building resilience, seems to be one of the key factors determining whether this resilience will be effectively leveraged to enhance organisational performance. Therefore, the following hypothesis can be formulated:

H3M2: The higher the systems thinking, the stronger the influence of the organisation's resilience on organisational performance. Systems thinking is

a moderator for the relationship between the organisation's resilience and organisational performance.

Finally, it is interesting to observe what happens when both of these factors act simultaneously. Not only can the two moderators independently influence the relationship between resilience and outcomes, but they can also interact with each other. In this context, the following hypothesis can be formulated:

H3M3: The higher the external support and systems thinking, the stronger the influence of the organisation's resilience on the organisational performance. External support and systems thinking are the moderators for the relationship between the organisation's resilience and organisational performance.

All developed hypotheses (and the three main research models), illustrating the relationships between external support, systems thinking, organisation's resilience, and organisational performance, are presented in Fig. 1. During the research process, simpler models, serving as the basis for the three main models presented below, were also built and tested, but they are not included in Fig. 1. However, they are described in detail later in the paper. The models shown in Fig. 1 (models 3, 5 and 7) are numbered according to the order in which they were developed and tested, which may cause some confusion.

2. Research methods

2.1. Data gathering process and characteristics of the research sample

To verify the proposed hypotheses, a quantitative survey was conducted. The results presented in this article are part of a broader research project entitled "Factors shaping Organisational Resilience", which focuses on the issue of organisational resilience. The project consists of a series of independent cross-sectional studies conducted at different points in time: on the eve of the Covid-19 pandemic (in December 2019) and shortly before its official end (in May and June 2023), preceded by pilot studies carried out in 2018. To ensure comparability, the definition of organisational resilience and its measurement approach remained consistent throughout all study periods, although it was further developed in each subsequent phase. The findings presented in this article are based on data collected in December 2019. The research was conducted anonymously using the online survey service SurveyMonkey among organisations located in Poland, and it was the only condition limiting the sample (organisations were surveyed regardless of size, industry or type of business, etc.). In each organisation, only one survey was conducted and completed by a manager with a comprehensive understanding of the organisation as a whole. The survey was directed at senior management and company owners. In total, 268 responses were collected. Due to the lack of data, the number in distinct cross-sections of the research sample (Table 1) is different. Purposive sampling was used. According to the size of the population of organisations operating in Poland, the sample cannot be considered representative; however, it is sufficiently diversified to be a basis for overall conclusions concerning the given topic. The characteristics of the sample, presented in Table 1, show its diversity in terms of size and types of organisations. The study includes both small, medium, and large entities, representing different business profiles. Approximately 60 % of the respondents represent enterprises of a local nature, while the remaining 40 % are organisa-

Tab. 1. Research sample characteristics

Size of the organisation Type of organisation	Micro (below 10 employees)	Small (10-49 employees)	Medium (50-249 employees)	Large (above 249 employees)	Total
Manufacturing	12	37	42	37	128
Trade	11	15	26	11	63
Service	9	11	24	28	72
Total	32	63	92	76	263
Age of organisation					
up to 5 years	8	13	5	0	26
6-10	9	22	39	7	77
11-15	11	23	37	34	105
over 20 years	4	5	11	35	55
Total	32	63	92	76	263

tions operating internationally (both independent units that are part of corporations and holding companies, and enterprises that maintain permanent links with foreign partners).

2.2. Variables measurement

To examine the proposed hypotheses, key variables were defined: external support, systems thinking, organisation's resilience, and organisational performance.

External support was measured based on six statements referring to the range of an organisation's collaboration with and outside industry, the intensity of networking, and the accessibility to external resources, which were developed based on articles (Lee et al., 2013; Seville, 2017; McCann, Selsky & Lee, 2009; Tengblad & Oudhuis, 2018). Respondents rated each statement on a 5-point Likert scale ranging from "I strongly disagree" to "I strongly agree", with a neutral option at the middle point ("I have no opinion").

Systems thinking was measured based on four statements reflecting the organisation's ability to identify, understand, and control key links, resources, and dependencies (both internal and external), and, in particular, the ability of incident analysis in the wider context of organisational processes and not as isolated incidents, or an awareness of the interdependencies between elements of the organisation and between the organisation and its environment. Here, the same 5-point Likert scale was used.

Variable organisation's resilience was built based on four properties assigned to the resilience of the system: robustness, redundancy, resourcefulness, and rapidity (Bruneau et al., 2003; Wicker et al., 2013). Within four properties, four measures (respectively, one item according to one property) of the organisation's resilience were indicated. They were rated on the 5-point Likert scale (from strongly disagree to strongly agree, with a middle point "I do not have an opinion").

Organisational performance was measured based on the Balanced Scorecard concept (Kaplan & Norton, 1996). That framework allows one to draw together multiple measures aimed at financial performance, internal business processes, customer perspectives, and innovation and learning. Within these four perspectives, ten measures of organisational performance were indicated. They were rated on the 5-point Likert scale (from well below expectations to well above expectations, with the middle point: as expected).

3. Research results

3.1. Descriptive statistics and reliability analysis of scales

As a first step in the research process, the reliability of the scales of each variable was verified. The results of the analysis of the reliability of the measurement scales are presented in Table 2. It is worth underlining that Cronbach's α was high for every variable, indicating a high internal reliability of the scales and measurements.

3.2. Relationships between external support, systems thinking, organisation's resilience, and organisational performance

As the next step of the analysis was the correlation analysis between external support, systems thinking, organisation's resilience, and organisational performance to verify hypotheses H1, H2, H3, H4, and H5 (Table 3). The results showed that the scope of external support is statistically significantly correlated with:

- Organisation's resilience ($r(256)=0.549^{**}$, $p<0.001$), which is the basis for positive verification of the hypothesis H1, and
- Organisational performance ($r(251)=0.484^{**}$, $p<0.001$), which is the basis for positive verification of the hypothesis H2,
- and the scope of systems thinking is statistically significantly correlated with:

Tab. 2. Defined variables, along with the results of the reliability analysis of scales

No.	Variable	No. of scales	Alfa-Cronbach	% var	M	SD
1	External support (ES)	6	0.824	53.313	3.42	0.95
2	Systems thinking (ST)	4	0.750	57.248	3.31	0.81
3	Organisation's resilience (OR)	4	0.809	63.659	3.29	0.87
4	Organisational performance (OP)	10	0.873	46.817	3.41	0.69

Tab. 3. Correlation analysis between the analysed variables

		Organisation's resilience	Organisational performance	External support
Organisational performance	r	0.541**		
	Sig.	0.000		
	N	247		
External support	r	0.549**	0.484**	
	Sig.	<0.001	<0.001	
	N	256	251	
Systems thinking	r	0.703**	0.538**	0.660**
	Sig.	<0.001	<0.001	<0.001
	N	252	247	251
**. *Correlation is significant at a level of 0.01 (two-sided)*				

- Organisation's resilience (r(252)=0.703**, p<0.001), which is the basis for positive verification of the hypothesis H4, and
- Organisational performance (r(247)=0.538**, p<0.001), which is the basis for positive verification of the hypothesis H5,

In all cases, correlations are positive, moderate to strong. The results obtained also showed that there is a positive, although rather moderate and statistically significant correlation between an organisation's resilience and organisational performance. It allows for the acceptance of the H3 hypothesis.

Summarising, the obtained results clearly show that there is a statistically significant and positive correlation between all the analysed variables; however, it is definitely the highest in the case of the relationship between the organisation's resilience and systems thinking. Systems thinking (ß=0.572, p<0.01) appeared to be a twice stronger predictor of the organisational resilience than external support (ß=0.247, p<0.01), and this model proved to be a good fit to the data (F(2, 247)=144.47; p<0.001; adj. R^2=0.535). In the context of the regression analysis planned in the next step, one of the most important research stages will be to check whether there is no multicollinearity between the predictors in the model.

3.3. External support and systems thinking as the moderators for the relationship between the organisation's resilience and organisational performance - research results

The relation between organisational resilience and organisational performance was analysed in the context of external support and systems thinking to verify whether these variables have the power to be statistically significant moderators of the relationship, the existence of which was verified above. Two alternative testing ways were used: stepwise regression analysis with moderator and Hayes PROCESS macro v. 4.2_beta designed for IBM SPSS Statistics software (Hayes Model 1 and Hayes Model 2). In the first step, the two considered moderators (external support and systems thinking) were entered into the model separately, and in the next step, simultaneously. To use the first research pattern, a few regression models were built:

- Research Model 1 was built as a base model for comparison, and only one independent variable (organisation's resilience) was included here as a predictor,
- Research Model 2 contained two predictors of organisational performance: the organisation's resilience and external support,
- Research Model 3 was built to verify the H3M1 hypothesis; in the model, in addition to the variables included in Research Model 2, a new variable - Moderator 1 - was introduced. The moderator variable was built as a product of two standardised independent variables (external support and organisation's resilience),
- Research Model 4 again contained two predictors of organisational performance: the organisation's resilience and systems thinking,
- Research Model 5 was built to verify the H3M2 hypothesis; in the model, in addition to the variables included in Research Model 4, a new variable - Moderator 2 - was introduced. The moderator variable was built as a product of two standardised independent variables (systems thinking and organisation's resilience),

Tab. 4. Multicollinearity statistics

Research Model	Predictors	Tolerance	VIF
Model 2	Organisation's resilience	0.530	1.885
	External support	0.530	1.885
Model 4	Organisation's resilience	0.506	1.976
	Systems thinking	0.506	1.976
Model 6	Organisation's resilience	0.403	2.480
	External support	0.463	2.159
	Systems thinking	0.429	2.328

Tab. 5. Regression models' statistics - Research Models 3, 5, and 7

Model description	R^2	Delta R^2	Moderator coeff.	Standard error	t Stat	P Value
Moderators treated separately						
Research Model 3: External support, Organisation's resilience, Moderator 1 (ORxES) *dependent v.:* Organisational performance	0.3940	0.0235	0.1090	0.0359	3.0396	0.0026
Research Model 5: Systems thinking, Organisation's resilience, Moderator 2 (ORxST) *dependent v.:* Organisational performance	0.3728	0.0345	0.1388	0.0384	3.6092	0.0004
Two moderators in one research model simultaneously						
Research Model 7: Systems thinking, External support Organisation's resilience,	0.4158					<0.001
Moderator 1 (ORxES)		0.0000	0.0035	0.0686	0.0508	0.9595
Moderator 2 (ORxST)		0.0097	0.1404	0.0717	1.9588	0.0513
Both moderators *dependent v.:* Organisational performance		0.0369				0.0009

- Research Model 6 contained three predictors of organisational performance: organisation's resilience, external support, and systems thinking,
- Research Model 7 was built to verify whether the moderating influence of external support and systems thinking is occurring in the sample when both are introduced into the model simultaneously (H3M3 hypothesis). To achieve this, two moderators (Moderator 1 and Moderator 2) were introduced as predictors in addition to the variables included in Research Model 6.

In the next step, the multicollinearity between the predictors in models 2, 4 and 6 was tested by calculating the tolerance and variance inflation factors (VIFs) for all predictors in the models. As shown in Table 4, the lowest tolerance was 0.403, which is far above the 0.1 benchmark. The largest VIF value was 2.480, which is well below the 10.0 benchmark, and this suggests that there is no obvious multicollinearity between the predictors in the model.

The obtained results clearly show that the external support and systems thinking, considered separately, are the moderators of the analysed relations. In both cases, the obtained models are statistically significant ($F(3, 238) = 51.583$, $p < 0.001$ for external support and $F(3, 237) = 46.948$; $p<0.001$ for systems thinking) and the delta R2 is also statistically significant too ($F(1.238)=9.2389$; $p=0.0026$ for external support and $F(1.237)=13.026$; $p=0.0004$ for systems thinking). Therefore, the results obtained are the

Tab. 6. Regression models' statistics - Research Models 1, 6, and 7

	Research Model 1			Research Model 6			Research Model 7		
	ß	t	p	ß	t	p	ß	t	p
Organisation's resilience (OR)	0.541	10.064	<0.001	0.190	2.332	0.021	0.156	2.382	0.0180
External support (ES)				0.279	3.669	<0.001	0.243	3.743	0.0002
Systems thinking (ST)				0,222	2.806	0.005	0.230	3.418	0.0007
Moderator 1 (ORxES)							0.004	0.051	0.9595
Moderator 2 (ORxST)							0.140	1.959	0.0513
Both									0.0009
R^2 (p)	0.290 (p<0.001)			0.3789 (p<0.001)			0.4158 (p<0.001)		
Delta R^2						0.089			0.0369

basis for the positive verification of hypotheses H3M1, confirming that external support is a moderator of the relationship between the organisation's resilience and the organisational performance, and hypothesis H3M2, confirming that systems thinking is a moderator of the relationship between the organisation's resilience and the organisational performance. In both cases, the Johnson-Neyman technique was used to identify regions in the range of the moderator variable where the effect of the focal predictor on the outcome is statistically significant and not significant. The conditional effect of organisation's resilience on organisational performance is positive and statistically different from zero when external support is greater than 2.184 (the moderation effect is statistically significant for low (b=0.1886, SE=0.061, t=3.0947, p=0.0022), average (b=0.2613, SE=0.057, t=4.5863, p<0.001) and high (b=0.3521, SE=0.0653, t=5.3911, p<0.001) moderator values). The conditional effect of organisation's resilience on organisational performance is positive and statistically different from zero when the systems thinking is greater than 2.5524 (however, the moderation effect is statistically insignificant for low (b=0.1234, SE=0.0677, t=1.8351, p=0.0677) moderator values, but significant for average (b=0.2631, SE=0.0596, t=4.4117, p<0.001) and high (b=0.3324, SE=0.0644, t=5.1616, p<0.001) moderator values).

In the last step of analysis, to verify the H3M3 hypothesis, the Hayes PROCESS macro v. 4.2_beta was used. The obtained model with two moderators appeared statistically significant (F(5.230)=32.7459; p<0.001), and the introduction of two moderators simultaneously significantly increased the percentage of explained variance of the dependent variable compared to research model 3 (by 2.18 %), research model 5 (by 4.3 %), and research model 6 (by 3.69 %), respectively. However, an interesting phenomenon can be observed here: external support is no longer a statistically significant moderator of the relationship between organisational resilience and organisational performance, while systems thinking is on the verge (slightly above the expected level of 0.05) of statistical significance. As Table 6 shows, the percentage of variance explained when organisational resilience effect is allowed to vary with both external support and systems thinking increases by 3.69 % and this increase is statistically significant (F(2.230)=7.2642; p=0.0009). Hence, it can be concluded, however with some caution, that the effect of organisational resilience on organisational performance is not independent of both external support and systems thinking, and the inclusion of both moderators has the power to change the relationship between organisational resilience and organisational performance. At least one of these variables (with an emphasis on systems thinking) moderates the discussed relationship when both are included in the model. The analysis of conditional effects shows that at a low level of systems thinking and all levels of external support, the moderation effect is not statistically significant. It becomes statistically significant only at the average and high levels of systems thinking, and on both of these levels, it increases with the increase of external support. Therefore, the results obtained are the basis for a partially positive verification of the H3M3 hypotheses, confirming that external support and systems thinking are moderators of the relationship between the organisation's resilience and organisational performance.

4. Discussion of the results

The purpose of this study was to explore how external support and the ability to understand sys-

temic linkages (an organisation's capability of systems thinking) influence the relationship between organisational resilience and organisational performance.

The results of the study confirmed that both external support and systems thinking have a positive impact on organisational resilience, which is consistent with studies previously discussed (Gao et al., 2022; Kim et al., 2021; Taneo et al., 2021; Xie et al., 2022; Xie et al., 2025; Liu & Yin, 2020). It was also found that systems thinking is more than twice as strong a predictor of organisational resilience as external support. These two discussed factors appeared also to be good and statistically important predictors of organisational performance, which confirms the statements of Ahuja (2000), Ecer et al. (2016) or Hereida et al. (2022).

The obtained results clearly show that the external support and systems thinking, considered separately, are statistically important moderators of the relationship between organisational resilience and organisational performance. This means that the same level of resilience can produce very different results depending on the available support. Organisations surrounded by partners that share information or acquire resources can rebuild faster and turn resilience potential into a competitive advantage. A lack of support, on the other hand, will translate into poorer organisational performance. In organisations that operate in a less favourable environment, external support compensates for deficits by strengthening the operation of resilience mechanisms. Thus, it also acts as an amplifier of the relationship under discussion. The same moderating effect is observed for systems thinking. Systems thinking can significantly change the way an organisation "cushions" its resilience by transforming it into organisational performance. Resilience without systems thinking can be short-sighted. If an organisation does not understand what connections and dependencies shape its environment, its actions in a crisis may be reactive and ad hoc. Systems thinking recognises the long-term effects of a crisis and anticipates new opportunities or threats. Thus, it conditions whether resilience will have a sustainable impact on performance. One of the key components of resilience is learning from one's own experience (Duchek, 2014; Duchek, 2020). Organisations that understand systemic dependencies are more likely to reflect on the causes of disruption, rather than just the symptoms. As a result, they draw more pertinent conclusions and make greater, more lasting changes that enhance their future competitiveness and performance. Low level of systems thinking and not considering the wider systemic context, in turn, means that even well-prepared, flexible, resilient organisations will fail to unleash the potential for efficiency and performance building.

And finally, it is very interesting to note the mechanism of synergistic effects of the factors studied. In organisations where systems thinking is strong and goes hand in hand with real relationship building, the positive impact of organisational resilience on organisational performance is stronger. However, the reinforcement effect does not occur at low levels of systems thinking. Organisations with a high capacity for systems thinking can better identify, source, and use available external support, which strengthens their ability to transform resilience into tangible results. In this case, the effect of one moderator is conditioned by the presence of another. This means that organisations with a high level of systems thinking make better use of available external support (e.g., by matching it to their priorities, integrating it into their activities, or more actively seeking such support), while access to support networks can in turn stimulate the development of systems thinking, e.g., through contact with more sophisticated partners or institutions.

Of the two considered moderators, a more important one is the ability to understand the linkages between the systems. Systems thinking is an internal moderator. This means that organisations can actively build this resource regardless of the environment. Although not every organisation can count on strong external support, the capacity for systems thinking can be developed in almost any organisation, making it a more universal tool for strengthening organisational resilience. Moreover, external support often acts in an ad hoc and reactive way to help an organisation survive in the face of a difficult crisis situation, while systems thinking also enables transformation, moving to a new, higher level of development. In that context, the ability to understand system linkages can be seen as a kind of lever that gives an organisation the chance not only to survive, but to gain a strategic advantage in a dynamically changing environment. And, finally, systems thinking enables the possibility of finding and using external support.

Conclusion

The main intention of this paper was to deepen the understanding of the relationship between

organisational resilience and organisational performance, considering the roles of two important moderators: external support (an external moderator) and systems thinking (an internal moderator). The results clearly show that the external support and systems thinking, considered separately, are the moderators of the analysed relationship. The model with two moderators is also statistically significant, and the introduction of two moderators simultaneously significantly increases the percentage of explained variance; however, an interesting phenomenon can be observed here. The analysis of conditional effects shows that at low levels of systems thinking and all levels of external support, the moderation effect is not statistically significant. It becomes statistically significant only at the average and high levels of systems thinking, and at both levels, it increases with growing external support.

The findings obtained raise very interesting practical and managerial implications and shed light on how organisations can build organisational resilience capacity beyond their own boundaries. The need to develop systems-thinking competence within an organisation appears to be one of the most important tasks facing managers. This means investing in the development of the ability to analyse the network of relationships -formal and informal - with external partners, suppliers, customers, or institutions of the environment, but also looking for tools to spot patterns in seemingly insignificant events. Organisations should implement training programmes and decision-support tools based on a systemic understanding of the effects of actions taken, and also seek instruments based on artificial intelligence. Although systems thinking is a more important moderator of considered relationships, the importance of access to resources and relationships with the environment should not be marginalised. Both factors can act complementarily to strengthen the adaptive capacity of enterprises. From a practical point of view, this implies the need to develop both systemic thinking competencies among managers and active management of interorganisational relationships. Organisations should not view their resilience in isolation from their network context. Focusing solely on their own assets and processes is not enough; they should also proactively identify critical dependencies in the environment and build mechanisms to jointly manage risk within the business ecosystem. In practice, this can mean, i.e., creating joint emergency procedures, integrating supply chain planning, or sharing information in real time. The ability to have a systemic understanding of interrelationships is not limited to external relationships. Equally important is the awareness of interdependencies within the organisation. Managers should therefore strive for better integration of processes, alignment of goals between organisational units, and the elimination of silos that hinder rapid response to disruptions. This requires, among other things, effective communication and an understanding that local optimisation does not always translate into system-wide benefits.

The presented empirical study has certain limitations that must be considered when interpreting the results. First, the sample size (268 organisations) and the sampling method do not allow it to be treated as representative of the entire population. Additionally, the analysis was conducted only in one specific business context, which limits the possibility of generalising the results to organisations operating in other countries or sectors. For this reason, it is worth considering the replication of the survey under different economic conditions in the future. However, the study results provide a solid starting point for further analysis of the role. Accordingly, future research should seek to verify the relationships presented in other sectors and market conditions and aim for a representative sample. This will not only increase the relevance of the results but also deepen the understanding of the contextual determinants affecting the relationship between organisational resilience, its moderators, and organisational performance.

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Sustainability in digital transformation: towards an integrated framework

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ABSTRACT

This paper investigates how existing literature has approached the concept of sustainability in the context of digital transformation.

It adopts a three-step procedure for a systematic literature review (SLR), including planning, conducting, and reporting the review to synthesise current knowledge, classify key thematic areas, and establish a foundation for further empirical research.

The findings emphasise the need for a structured and sustainable approach to digital transformation to enhance business resilience and effectiveness. Although this is a relatively new and emerging topic, and there is a lack of a solid conceptualisation of the role of sustainability in digital transformation, several important theoretical implications can still be identified.

By addressing the fragmented nature of the literature, this study contributes to the field by developing a structured framework for classifying key areas of sustainability in digital transformation. The systematic literature review revealed an absence of a unified conceptualisation and a lack of consistent understanding of sustainability in digital transformation across the analysed publications. Nevertheless, the study successfully identified 24 areas related to the sustainability of digital transformation, which were categorised into a framework comprising four fields: people, management, technology, and environment.

The study plays a crucial role in enhancing the understanding of the sustainability of the digital transformation process by using a classified set of sustainability areas within it. The study results provide practical information for managers leading digital transformation processes in companies.

KEY WORDS

sustainability, sustainable digital transformation, digital transformation, information systems, sustainable management, systematic literature review

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Introduction

Over the past decade, digital transformation has become a defining force in reshaping industries, economies, and societies (Kraus et al., 2021; Omol, 2024; Pappas et al., 2023; Verhoef et al., 2021). As organisations invest heavily in technologies, such as artificial intelligence, cloud computing, and the Internet of Things (IoT) (Al-Sharafi et al., 2023; Babina et al., 2024; Lee & Lee, 2015), the scale and speed of transformation continue to accelerate (Chaudhuri et al., 2024). Global expenditure on digital transformation is expected to reach USD 2.8 trillion by 2025 -

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more than double the amount spent in 2020 (Pacolli, 2022). By 2030, nearly one trillion devices are projected to be connected to the Internet (Pînzaru et al., 2019), while an estimated 40 % of current market leaders may be displaced due to the lack of viable digital strategies (Hoa & Tuyen, 2021).

At the same time, this rapid evolution has raised critical concerns (Dąbrowska et al., 2022; Rowe, 2018; Soto-Acosta, 2024). When digital transformation initiatives are misaligned, underestimated, or implemented without foresight, they may become sources of disruption and harm socially, economically, and environmentally (Carnerud et al., 2020; Flyverbom et al., 2019; Ghobakhloo, 2020). These risks have catalysed growing interest in the concept of Sustainability of Digital Transformation (SDT) - a convergence of two major trends in contemporary management: digitalisation and sustainability (Kupilas et al., 2022; Lichtenthaler, 2021).

This paper addresses that gap by conducting a systematic literature review (SLR) on the sustainability of digital transformation. The review consolidates scattered insights, identifies key thematic dimensions, and offers a classification framework that may inform future empirical research. In doing so, the paper contributes to both the conceptual clarification and operationalisation of SDT.

In this study, digital transformation is defined according to Vial as "a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication and connectivity technologies" (Vial, 2019) Sustainability is examined through the lens of the Triple Bottom Line (TBL) framework (Elkington, 1997), which considers economic, social, and environmental dimensions. While this framework provides a useful starting point, the review also explores whether these three pillars sufficiently capture the complexity of SDT, or whether additional dimensions, such as ethical, governance, or resilience aspects, should be included.

Accordingly, this paper seeks to answer the following research questions:

RQ1: How has scholarly research approached the topic of the sustainability of digital transformation?

RQ2: How are the dimensions of sustainable digital transformation understood and classified?

To address these questions, a systematic literature review was conducted, identifying key contributions at the intersection of digital transformation and sustainability, and evaluating their methodological and conceptual approaches. It aims to provide a clearer understanding of the state of the art, propose an integrative classification of sustainability dimensions in SDT, and lay the groundwork for developing robust research models to guide future inquiry.

1. Literature review

While the term sustainability is typically associated with long-term environmental, social, and economic development (Bai et al., 2020; Huang et al., 2024; Owusu & Asumadu-Sarkodie, 2016), sustainable digital transformation entails a more specific interpretation (Costa Melo et al., 2023; Nyagadza, 2022). In this context, sustainable refers to the ability of organisations to implement digital transformation in a way that maintains long-term value creation across multiple dimensions (Ciachorowski & Miranda, 2025). This is not limited to reducing environmental impact but includes ensuring that technological advancement is resilient (Garcia-Perez et al., 2023), ethically governed (Saarikko et al., 2020), inclusive (Di Vaio et al., 2021), and strategically integrated (Schwarzmüller et al., 2018).

The literature on SDT, however, remains fragmented (Dang et al., 2024; Hanelt et al., 2021). Diverse conceptualisations coexist (Ayoubi et al., 2023; Guandalini, 2022; Matt et al., 2015), which often emphasise isolated dimensions, such as technological innovation (Romanello & Veglio, 2022), environmental impact (Liu et al., 2022), human-centred design (Brauner & Ziefle, 2022), or managerial approaches (Ionescu et al., 2022), without offering an integrated understanding of how these dimensions interrelate. The multidimensionality of SDT, combined with a lack of conceptual clarity, may lead to inconsistent interpretations and hinder effective implementation (Ayoubi et al., 2023; Gimpel et al., 2018; Guandalini, 2022). Moreover, the unprecedented pace of technological innovation, particularly in AI, further complicates the management of transformation processes (Caputo et al., 2021).

A number of models and frameworks have been proposed to guide digital transformation efforts (Bai et al., 2017; de Camargo Fiorini & Jabbour, 2017; Rachinger et al., 2019; Urbinati et al., 2020), yet they differ widely, especially when they attempt to incorporate sustainability principles. Most frameworks emphasise economic or technological aspects, with limited integration of social or environmental concerns (Frank et al., 2019). Few studies attempt a holistic perspective that acknowledges the full

spectrum of sustainability dimensions (Kamble et al., 2020). This conceptual gap necessitates a comprehensive synthesis of existing research.

2. Research methods

To clarify the current state of research on sustainable digital transformation, this paper adopts the three-step procedure for a systematic literature review (SLR), proposed by Tranfield (2003), which includes planning, conducting, and reporting the review. This approach offers a transparent process for carrying out the SLR, provides the flexibility to explore emerging scientific themes, and ensures the use of appropriate tools and methods.

2.1. Planning the review

This review focused on papers published in the Scopus and Web of Science (WoS) databases. The two databases were selected because they are among the most comprehensive and representative sources of academic literature. Despite their individual features, there is substantial overlap between them, meaning that most high-quality research is indexed in both. Second, given the very rapid pace of development in digital technologies, this study covers the seven-year period from 2018 to 2024, corresponding to the time frame leading up to the start of this review. Third, the need for a systematic literature review on the sustainability of digital transformation arises from the fragmented nature of the literature. To identify potentially overlooked or under-researched areas, it is essential to adopt an interdisciplinary approach that integrates diverse perspectives, thereby laying a solid foundation for the design of future empirical research. For this reason, the authors did not impose additional selection criteria based on journal ranking or impact factor. The initial phase of the review process aimed to identify and summarise the literature on the subject, highlight research gaps, assess the suitability of the selected area for further research, and evaluate its relevance for practitioners. The work began with the selection of keywords, which were then used during the article screening phase across relevant databases. The literature review utilised combinations of Boolean operators and the following search strings:

(TITLE-ABS-KEY ("sustainable digital transformation") OR TITLE-ABS-KEY (sustainab* AND "digital transformation") OR TITLE-ABS-KEY (sustainab* AND digitisation) OR TITLE-ABS-KEY (sustainab* AND digitization) OR TITLE-ABS-KEY (sustainab* AND digitalization) OR TITLE-ABS-KEY (sustainab* AND digitalisation) OR TITLE-ABS-KEY ("industry 4.0") OR TITLE-ABS-KEY ("industry 5.0"))

The first keyword combination, "sustainable digital transformation", captures the essence of the study. To explore this multidimensional concept in depth, this paper uses a set of interrelated keywords. The first of these is "sustainability," which, in the context of digital transformation, refers to technological advancement that reduces negative environmental impacts while enhancing social benefits. Sustainability combined with "digital transformation," a process of technological change that can transform business models, organisational processes and even the way societies function, forms the conceptual foundation of this study. Additionally, the keywords "Industry 4.0" and "Industry 5.0" were used to target research that emphasises a changing vision of digital transformation from automatisation and efficiency-driven transformations to long-term development driven by human-centric values and organisational resilience. The combination of search terms was used to search titles, abstracts and keywords: "digital transformation" or "digitisation"/"digitization" or "digitalisation/digitization". The terms "digitisation" and "digitalisation" are also discussed in the literature, where they are often used interchangeably with the term "digital transformation", but more precisely represent an integral stage of the transformation process involving the implementation of digital technologies into traditional business processes. The combination of these keywords used created a comprehensive and targeted research framework, enabling a broad yet precise search across titles, abstracts and keywords of relevant scientific papers.

2.2. Conducting the review

The combination of keywords appeared in 114,313 items overall, but only 13,373 from the Scopus database (under the category "Business, Management and Accounting") and 6,044 from the Web of Science database (under the category "Management and Business") were related to management science. Further filtering was applied to the set of publications using broad search parameters, excluding articles that did not meet the established criteria. Fig. 1 presents a graphical representation of the process, detailing the filtering criteria applied at each screening phase. The selection process was divided into three screen-

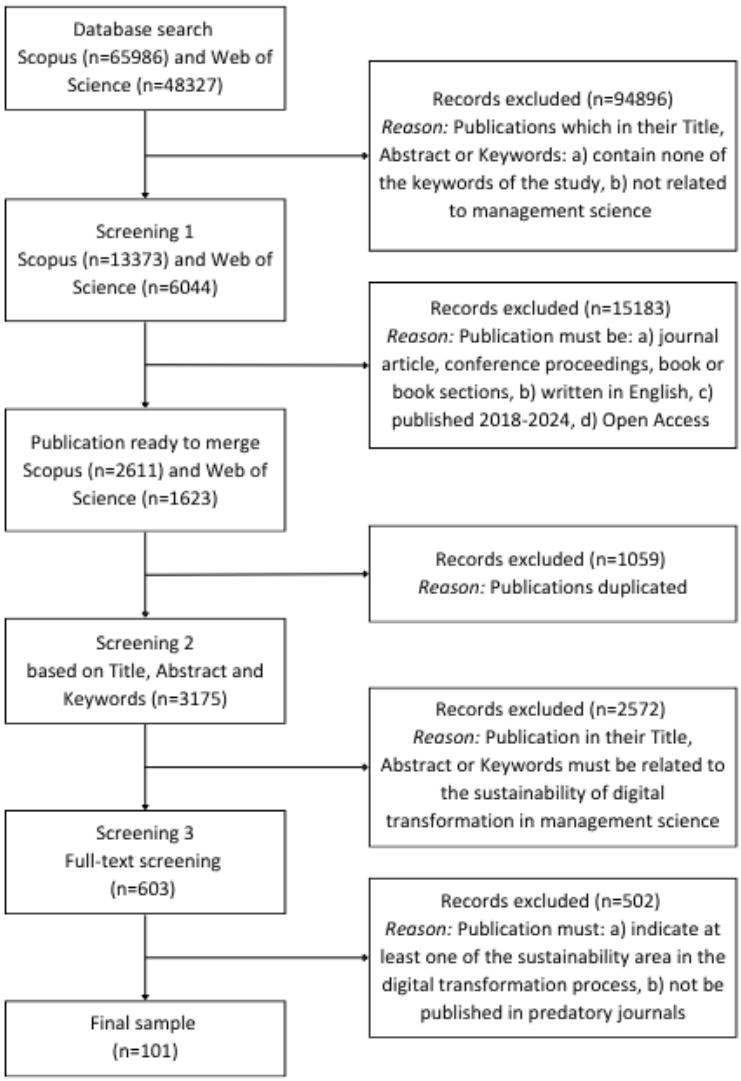

Fig. 1. Systematic literature review process

ing phases, each disqualifying articles that failed to meet certain specific criteria for further analysis.

In the first phase, the selection criteria focused on compliance with the types of publication specified in the initial analysis phase. The literature had to be in one of four forms: journal articles, conference proceedings, books or book chapters. Compliance with both the key terms and publication types was defined to ensure that selected items addressed broadly understood management in organisations, with a particular emphasis on the sustainability of digital transformation. The second criterion was the language of publication (English), and the third was the publication date; only articles published between 2018 and 2024 were included to ensure relevance to current management trends. The final criterion concerned accessibility; articles without available full-text access were excluded.

Applying these filters resulted in 2611 publications from the Scopus database and 1623 from the Web of Science database qualifying for further analysis. After merging both databases and removing duplicates, 3175 unique articles remained for analysis, which were subjected to further selection criteria.

The second phase of selection focused on publications specifically addressing the sustainability of digital transformation in organisational management. Each publication was evaluated based on its abstract, title and keywords. Only those clearly related to the sustainability of digital transformation within the

context of management science were selected for further analysis. This phase resulted in 603 articles being accepted for the next stage of selection.

The final selection phase involved a full analysis of the articles to assess their alignment with the concept of sustainability of the digital transformation process. It was essential that the publications either identified sustainability-related areas relevant to ongoing digital transformation or that the authors highlighted the unique impact of a specific aspect of organisational development on the transformation process.

The study did not exclude publications from lower-ranking journals, as the goal was to gather a broad range of sustainability-related areas within the digital transformation process. At this stage, the collected literature serves as a basis for classifying these areas. The evaluation of the relevance and impact of individual areas will be the subject of further empirical research, during which areas of negligible relevance will be excluded from future modelling of a framework for sustainable digital transformation. Additional selection criteria involved excluding all articles from predatory journals, as they are considered less reliable sources of knowledge. The remaining 101 articles formed the basis for further work

2.3. Reporting

After all the screening phases were completed, the selected articles were subjected to descriptive and thematic analyses. The descriptive analysis focused on examining publications in terms of recognition and citation metrics, research approaches and methods used, and industrial scope. The detailed data collected and analysed during this phase are presented in Appendix 1. The thematic analysis, in turn, identified the most important thematic threads addressed in the selected publications. Additionally, it served as the foundation for identifying the key areas that constitute the sustainability of digital transformation and for developing its preliminary framework.

3. Research results

3.1. Descriptive analysis

The descriptive analysis closely aligned with RQ1, which focused on determining how existing research has approached the topic of the sustainability of digital transformation. Prior to the COVID-19 pandemic (Abilova & Aliyeva, 2022), digital transformation in enterprise management was not a leading topic in the literature, especially in the context of sustainability. Since 2020, however, there has been a clear upward trend in the number of publications advocating for a broader perspective on digital transformation that goes beyond financial optimisation and technological enterprise growth. Entrepreneurs and researchers studying the implementations of new technologies are increasingly seeking more effective methods of technology adaptation that lead to lasting organisational change. These approaches emphasise long-term outcomes, even if they come at the cost of short-term profitability.

The growing interest in the sustainability of digital transformation is also reflected in the increasing number of citations of the analysed publications, although the overall citation count remains relatively average. From the pool of 101 selected articles, the median number of citations is 38, while the 10 most cited articles (Casciani et al., 2022; Liu et al., 2022; Ching et al., 2022; George & Schillebeeckx, 2022; Del Giudice et al., 2021; Guandalini, 2022; Ghobakhloo et al., 2021; Kamble et al., 2020; Gil-Gomez et al., 2020) received at least 237 citations, with the most frequently cited article by Carayannis and Morawska-Jancelewicz (2022). In the sample of articles included in the study, 11 out of 350 authors appeared more than once; most frequently, these were Iranmanesh and Ghobakhloo (three times) (Ching et al., 2022; Ghobakhloo et al., 2021, 2024). This suggests that there is no dominant author in the field of sustainable digital transformation.

Similarly, the analysis did not reveal the existence of a single journal that consistently published articles on sustainable digital transformation. On the contrary, sustainable development in digital transformation seems to be of interest to a wide range of editors and, consequently, to the wider academic community. However, the journal Business Strategy and the Environment deserves attention, with as many as five articles appearing in the sample for this study. Among the 81 journals and conference proceedings, 14 published at least two articles.

The high diversity of scientific journals is also reflected in the diverse origins of the authors. As shown in the table (Table 1), the authors contributing to the presented systematic literature review (SLR) come from all continents. However, the concept of digital transformation sustainability within management is predominantly explored by scholars affiliated with European institutions, who represent over 60 %

Tab. 1. Global distribution of authors by continent

Continent	All authors		Primary author	
	Number of countries	Number of authors	Number of countries	Number of authors
Europe	22	224	19	63
Asia	12	86	9	26
Africa	4	13	3	4
North America	3	14	2	4
South America	1	12	1	2
Australia	1	9	1	2
sum	43	358	35	101

of all contributing authors. This trend remains consistent even when considering only primary authors. Asia ranks second in terms of author representation, accounting for 24 % of the total. In contrast, the concept of sustainable digital transformation appears to be more popular among authors from other continents, though their representation ranges only from 2 % to 4 %. Among the 43 countries included in the study, authors affiliated with German institutions dominate, contributing about 12 % of the publications, followed by those with Spanish, Italian and British affiliations, each representing between 7 % and 8 % of publications. The first Asian country affiliation in the list is Indonesia, with 6 % representation. North America and Africa account for only 4 % each, while countries from other continents each contribute less than 2 %.

The next stage analysed the research approaches and methods used in the selected set of papers. The early phase of research on sustainable digital transformation is evidenced by the predominance of conceptual (54 %) and exploratory (47 %) studies. Most of the selected papers focus on identifying and understanding the emerging phenomenon of sustainability of digital transformation, along with related challenges that were previously unknown or poorly understood.

This is further supported by the employed research methods. Most studies (approx. 68 %) used qualitative methods, while only 14 % were based on quantitative data. The reliance on qualitative approaches reflects the need for in-depth analysis of this relatively new phenomenon of sustainable digital transformation. In the initial stages of research, it is essential to understand the context and gain a deep insight into the phenomenon from the participants' perspectives. The chosen methods enable more effective analysis of cases involving a novel or unexpected result in this area. Qualitative methods are especially valuable in interdisciplinary research, as they facilitate a comprehensive understanding of complex and evolving phenomena. They support exploration through a holistic, participatory approach to learning.

It is noteworthy that more than 62 % of the analysed publications base their research on secondary data. This may suggest the use of a wide range of available sources, including publications, reports, studies, and statistical data, which allow for deeper contextualisation of the researched problem. Only 12 % of the analysed publications rely on primary data, indicating that the authors pursued a specific research objective that required original, previously unpublished data. Around 26 % of the analysed publications use a mix of primary and secondary data, which may reflect an effort to strengthen research findings through triangulation.

Deepening the methodological analysis, it was observed that although the authors of the analysed publications employed various data collection methods, 45 % relied on a single method, typically a literature review or the use of existing data. In the remaining publications, two (45 %) or three (11 %) data collection methods were used. The use of surveys (20 %), interviews (19 %), and case studies (11 %) reflects the authors' efforts to identify research gaps and analyse previously observed patterns.

The final step of the descriptive analysis focused on the industrial scope. Of all the publications analysed, nearly 52 % addressed multiple industries, while about 48 % focused on a single, specific industry. Most of the publications referred to the broadly defined business sector without specifying company size or the nature of the activity. The most frequently mentioned sector was the manufacturing industry (including manufacturing, steel, food and fashion), followed by the logistics and supply chain management, and agriculture and natural resources.

3.2. Thematic analysis

The thematic analysis aimed to answer RQ2, which concerns "how areas of sustainability of digital transformation are identified and understood in the literature".

The SLR-based analysis shows that the sustainability of digital transformation, considered a key element in the evolution of contemporary organisations (Ananyin et al., 2018), is a multidimensional concept (Andriushchenko et al., 2020) subject to various interpretations in scientific literature (Braukmann et al., 2023) and business practice (Beier et al., 2022; Branca et al., 2020). A comparison of different definitions of this phenomenon (Guandalini, 2022; Haryanti et al., 2023; Lammers et al., 2018) reveals a wide range of perspectives (Camarinha-Matos et al., 2024), highlighting the technological (Schuh et al., 2021), organisational (Broo & Schooling, 2023) and sociocultural (Casciani et al., 2022) dimensions of the digitisation process. These discrepancies reflect not only technological evolution, but also the shifting expectations and needs of stakeholders (Abdallah et al., 2022), which directly influence how organisations undertake and implement digital transformation strategies (Alfarizi & Widiastuti, 2023).

All of the analysed articles aimed to optimise enterprise activities in the context of digital transformation through actions related to sustainability. The sustainability areas addressed varied across enterprises, regardless of the industry covered in each publication. Based on the analysis, the authors of this article identified 24 distinct areas of sustainability within digital transformation. The table (Table 2) presents these areas along with the meanings as derived from the selected publications.

The most frequently addressed areas were environmental (81 % of publications), technological (75 %), social (73 %), and economic (72 %). The authors of these publications highlighted connections to the sustainability framework known as the Triple Bottom Line (Loviscek, 2021), a concept introduced by John Elkington in 1994 (Elkington, 1997). This marked a pivotal shift in strategic thinking about the role of enterprises in relation to sustainability. The areas of sustainability are defined as follows: the social dimension emphasises a collective approach to transformation, aiming to ensure that change positively impacts communities by democratising processes, improving access to technology, and investing in human capital; the environmental dimension focuses on actions that result from environmental transformation such as changes in energy used for production, waste management, and carbon footprint reduction; the technological dimension relates to technological innovation, digital inclusion, and the development of sustainable digital technologies. The economic dimension involves cost optimisation through the use of technology, as well as consideration of non-financial aspects of business operations.

On average, the emerging areas include organisational agility (26 % of publications), which focuses on adaptability, speed, and customer orientation. The human dimension (22 %), which considers individuals and their roles and impacts; culture (21 %), referring to the creation of values within the company along with interpersonal norms and rules; governance (19 %), which pertains to the principles of management and control within the organisation; and ethics (11 %), which involves adherence to rules and laws throughout the product life cycle; knowledge and support (11 %), which involves knowledge sharing and training; process (11 %), which focuses on the design of workflows and the interrelations between people and tasks within the organisation;. These areas appeared most frequently in articles discussing digital transformation driven by algorithms and artificial intelligence tools.

The next set of sustainability areas in digital transformation processes identified by the authors of this article are those that appeared infrequently in the reviewed publications. However, given the very rapid development of artificial intelligence, these areas may grow in importance in the coming months and years. These include areas focused on implementing digital business development strategies (business sophistication - 9 %); operational (8 %), which concerns the optimisation and implementation of organisational processes; developing appropriate infrastructure to support technology (infrastructural - 8 %); ensuring integration with the external environment in a digital context (external - 6 %) and fostering innovation and creativity (creative outcomes - 5 %).

The least frequent areas were those that appeared only several times, each constituting 4 % of the analysed publications. These areas include structural which focuses on the materials used in construction; legal, which addresses legal considerations; individual, which refers to the personal impact of digital transformation on individual stakeholders; adapting to rapidly changing market conditions (market sophistication); promoting collaboration across all parts of the organisation (organisational ecosystem), and enhancing customer interaction through tech-

Tab. 2. Sustainability areas of digital transformation

No.	Name of the sustainability area	Adopted meaning of the area for the purpose of identification	References (examples)	Number of publications (n=101)
1.	Environmental	Minimising the environmental impact of technology.	(Calafat-Marzal et al., 2023; Cali et al., 2023; Ching et al., 2022; Ghobakhloo et al., 2021; Guandalini, 2022; Pérez Perales et al., 2019; Pinzaru et al., 2022; Popovs & Drinke, 2022; Weber-Lewerenz, 2021)	82
2.	Technological	Implementing new technologies.	(Abiodun et al., 2023; Chatzistamoulou, 2023; Chavez et al., 2022; Del Giudice et al., 2021; Fareed et al., 2024; Gil-Gomez et al., 2020; Ionascu et al., 2022; Li et al., 2024; Liu et al., 2022; Luo & Liu, 2024)	76
3.	Social	Building responsible digital practices for society.	(Kamble et al., 2020; Singh & Maheswaran, 2023; Spaltini et al., 2021; Straková et al., 2022; Trstenjak et al., 2023; Tyagi et al., 2024; Zaychenko et al., 2021)	74
4.	Economic	Increasing efficiency and generating economic value.	(Barmuta et al., 2020; Beier et al., 2022; Bhagat et al., 2022; Branca et al., 2020; Braukmann et al., 2023; Camarinha-Matos et al., 2024; Ghobakhloo et al., 2024; Margherita & Braccini, 2023)	73
5.	Organisational agility	Increasing the company's flexibility to respond to change.	(Broo & Schooling, 2023; George & Schillebeeckx, 2022; Jayashree et al., 2022; Kupilas et al., 2023; Otero Mateo et al., 2018; Pînzaru et al., 2019; Walter Colombo et al., 2021)	26
6.	Human	Improving working conditions through technology.	(Carayannis & Morawska-Jancelewicz, 2022; J. Chen et al., 2023; Gerhátová et al., 2021; Kupilas et al., 2022; Pacolli, 2022; Pappas et al., 2023)	22
7.	Cultural	Shaping a technology-friendly organisational culture.	(Abdallah et al., 2022; Abilova & Aliyeva, 2022; Alfarizi & Widiastuti, 2023; Casciani et al., 2022; Haryanti et al., 2023; Schuh et al., 2021; Shang & Zhang, 2022)	21
8.	Governance	Implementing effective digital management strategies.	(Ananyin et al., 2018; Andriushchenko et al., 2020; Caraveo Gomez Llanos et al., 2023; L. Chen et al., 2023; Chipangamate et al., 2023; Grishunin et al., 2022)	19
9.	Ethical	Ensuring ethical standards in digital operations.	(Appiah-Nimo & Chovancová, 2020; Brauner & Ziefle, 2022; Jimenez et al., 2022)	11
10.	Knowledge and support	Development of competence and availability of technical support.	(Gatell & Avella, 2024; Keefe et al., 2024)	11
11.	Process	Digitisation and automation of business processes.	(Narkhede et al., 2024; Sezer et al., 2024; Valdez-Juárez et al., 2024; Nyagadza, 2022)	11
12.	Business sophistication	Implementing digital strategies for business development.	(Ionescu et al., 2022; Siswanti et al., 2024a, 2024b)	9
13.	Operational	Optimising operational processes with digital tools.	(Abad-Segura et al., 2024; Arranz et al., 2023; Ayoubi et al., 2023)	8
14.	Infrastructural	Building appropriate infrastructure to support technology.	(Arroyabe et al., 2024; Phiet, 2023)	8
15.	External	Integrating with the external environment in a digital context.	(Y. Chen et al., 2024; Leberruyer et al., 2024; Oubrahim & Sefiani, 2023)	6
16.	Creative outcomes	Stimulating innovation and creativity in the organisation.	(Arroyabe et al., 2024)	5
17.	Structural	Modifying organisational structures in response to technology.	(Lammers et al., 2018; Romanello & Veglio, 2022)	4
18.	Legal	Alignment with technology regulations.	(Ferrari et al., 2022; Ionescu et al., 2022)	4
19.	Individual	Personalisation of technology for individual user needs.	(Christmann et al., 2024; Dash et al., 2023)	4
20.	Market sophistication	Adapting to rapidly changing market conditions.	(Bezerra et al., 2024; Rodriguez Santiago, 2024)	4
21.	Customer experience	Improving customer interaction through technology.	(Mihardjo et al., 2019; Sezer et al., 2024; Valdez-Juárez et al., 2024)	4
22.	Organisational ecosystem	Creating collaboration between all parts of the organisation.	(Arroyabe et al., 2024; Carlos et al., 2024; Parmiggiani & Mikalef, 2022; Sun et al., 2024)	4
23.	Psychological	Nurturing the impact of technology on psychological wellbeing.	(Bezerra et al., 2024; Keefe et al., 2024)	3
24	Political	Establishing relationships with political and regulatory stakeholders.	(Peretz-Andersson & Torkar, 2022)	1

Tab. 3. Framework of the areas of the sustainability of digital transformation

No.	Field name	Subgroup name	Digital transformation sustainability area name	References (examples)
1.	Technology	Tools	• Technological • Infrastructural • Structural	(Broo & Schooling, 2023; Cali et al., 2023; Del Giudice et al., 2021; Guandalini, 2022; Winarsih et al., 2021)
		Actions	• Operational • Process	(Abad-Segura et al., 2024; Arranz et al., 2023; Ayoubi et al., 2023; Narkhede et al., 2024; Nyagadza, 2022; Sezer et al., 2024; Valdez-Juárez et al., 2024)
2.	Management	Organisational	• Governance • Organisational agility • Organisational ecosystem	(Arroyabe et al., 2024; Carlos et al., 2024; Parmiggiani & Mikalef, 2022; Popovs & Drinke, 2022; Sun et al., 2024)
		Strategic	• Business sophistication • Economical • Market sophistication • External • Legal • Ethical	(Chernova et al., 2023; Ferrari et al., 2022; Gil-Gomez et al., 2020; Klungseth et al., 2023; Pérez Perales et al., 2019)
3.	People	Single	• Customer experience • Individual • Knowledge and support • Creative outcomes	(Narkhede et al., 2024; Pacolli, 2022; Phiet, 2023; Sezer et al., 2024)
		Multiple	• Social • Human • Psychological • Cultural • Political	(Carayannis & Morawska-Jancelewicz, 2022; Ghobakhloo et al., 2021; Kürpick et al., 2023; Münnich et al., 2023)
4.	Environment	Environment	• Environmental	(Calafat-Marzal et al., 2023; Grishunin et al., 2022; Junge & Straube, 2020; Kamble et al., 2020; Lichtenthaler, 2021; Ogrean, 2023)

nology (customer experience). Additional areas include areas focused on managing the impact of technology on psychological wellbeing (psychological - 3 %) and political (1 %), which encompasses policy-related influence.

Due to the large number of sustainability areas, it was necessary to classify them in order to simplify the structure and illustrate how the areas relate to one another. From the authors' perspective, it was important and fundamental to determine whether each sustainability area concerned technology-related or people-related areas. To support this classification, the following question was posed for each area: Does the sustainability area relate to technology, people, both technology and people, or neither?

Based on the responses to the question, four groups of sustainability areas were identified.

If the answer to the question was either "technology" or "people", it corresponded to the respective sections in the table (Table 3). If the answer was "technology and people", then it corresponded to the "management" section of the table. If the answer was neither "technology" nor "people", then it was classified under the "environment" section, as this was the only sustainability area that did not fit into the previous categories.

The division into four groups of areas helped simplify the understanding of the identified areas of digital transformation sustainability, but it was not sufficient to clearly structure the entire network of connections. Therefore, the authors introduced a further subdivision within each group to better assign the areas based on their functionality and importance. This refined classification is presented in the table (Table 3).

The proposed division breaks down the "technology" field into two subgroups: "tools" refers to various tools, machines, equipment, and other products used in the digital transformation process; and "action" encompasses all the activities and operations carried out during this process. The "people" field is divided into two subgroups based on the number of individuals involved: "single", for activities performed by and for one person, and "multiple", for activities involving more than one person. The field that combines technology and people, "management", is further divided into two subgroups: "organisational", which relates to the implementation of activities at the operational level, and "strategic", which pertains to the higher-level strategic planning. "Environment" contains only one area of sustainability and, as such, retains the same subgroup name.

4. Discussion of the results

This study primarily aimed to review articles in the field of Sustainable Digital Transformation (SDT) to understand how the topic of sustainability in digital transformation is addressed. The review identified 101 publications providing insights into how the concept is currently understood. Despite the large number of publications on digital transformation studies that specifically focus on the sustainability aspect and that define specific areas of sustainability, the interest is rather limited. Most of the articles focus on the dominant dimensions of social, economic, and environmental sustainability. Although this is a relatively new and emerging topic, and there is a lack of a solid conceptualisation regarding the role of sustainability in digital transformation in transformational processes, several important theoretical implications can still be identified.

First, building on the foundational work of Vial (2019) and Elkington (1997), the authors identified a significant relationship between sustainability and digital transformation, both of which are key to long-term corporate strategy.

Second, the systematic review highlights a lack of consensus and consistent understanding regarding sustainable digital transformation across the analysed literature. In response to the identified problems occurring both in the scientific environment and among entrepreneurs, the authors of this SRL tried to conceptualise the approach to the sustainability of digital transformation by indicating the main fields of this concept.

Third, as the current study has shown, interest in sustainable digital transformation is observed in most industries, regardless of the size and technological sophistication of companies. Digital transformation is no longer the domain of only large companies or high-tech sectors. Even smaller and less advanced companies are seeing the value in such activities, and consequently, sustainability is becoming a key criterion in digital transformation, changing the way we think about technological development. What is more, the topic is attracting the interest of more and more researchers every year, as evidenced by the 100 % year-on-year increase in the number of publications addressing the sustainability of digital transformation. Interest in sustainable digital transformation has been noted on all continents, but the narrative in ongoing research is dominated by European authors.

Fourth, the development of the sustainability of digital transformation involves multiple interactions between the identified areas, which can create possible challenges and threats. The identified areas of the sustainability of digital transformation are associated with the novelty of the subject, and exploring this topic will provide a better understanding of the interrelationships between areas in order to create an optimal strategy for implementing a sustainable digital transformation.

Fifth, it is worth mentioning some methodological strengths of the current study. The present review, applying a systematic review methodology, scopes the whole field of the sustainability of digital transformation, not limited only to the most popular sustainability concepts, thanks to which it is more robust. It is worth noting that the inclusion of articles describing the sustainability of the digital transformation process from different types of academic journals adds value to this study, as we map the different areas of the sustainability of digital implementations, uncovering their key findings as well as their main concepts. Omitting perspectives presented in weaker journals could be to the detriment of further quantitative research, as this systematic literature review aims to identify all areas of sustainability of the digital transformation process from articles meeting the defined rigorous selection criteria. Further empirical research will select the identified areas of digital transformation sustainability in relation to their relevance and importance.

Last, by developing a framework that systematises the fragmented literature, it shows all the dimensions of sustainable digital transformation and groups them together. In this way, it provides a comprehensive approach to the topic, which is a good starting point for defining sustainable digital transformation, which is difficult but becomes easier if defined areas are used. This study enables future researchers to explore the different possible implications regarding the areas of sustainable digital transformation and increase their understanding with regard to the underlying mechanisms and conditions under which digitalisation will bring certain outcomes.

Conclusions

This study highlights the importance of a more robust and more effective business transformation by adopting a structured and sustainable approach to digital transformation. It plays a crucial role in

enhancing the understanding of the sustainability of the digital transformation process by using a classified set of sustainability areas in the transformation process. The results of this study provide practical information for managers leading digital transformation processes in companies.

First, the study highlights the need to integrate sustainability principles into the digital transformation process, supporting long-term value creation beyond immediate technological advances.

Second, managers carrying out a digital transformation process should take a multidimensional and inclusive approach to such a process, considering not only the technological aspects of implementations, but also focusing on the human, managerial and environmental aspects.

Third, the proposed breakdown structure supports practitioners in mapping and categorising the various aspects related to the sustainability of digital transformation. This will make the management of the digital transformation process more structured and harmonised.

Fourth, the findings of this study are also applicable to policymakers, highlighting a gap in the institutional mechanisms developed that do not consider the sustainability of digital transformation. Regulatory frameworks should encourage companies to adopt responsible digitalisation practices based on human-environment-technology synergies.

Fifth, the identified fields and areas of digital transformation sustainability provide the basis for a diagnostic tool to assess an organisation's readiness for sustainable digital transformation to help organisations to prioritise long-term digital transformation planning.

Last, the proposed framework can be applied to companies regardless of their size or sector, making it a versatile tool for organisations seeking a structured and sustainable way to carry out digital transformation. By adopting this approach, companies can increase their competitiveness, ensure compliance and drive efficiency through the synergy of humans, the environment and technology.

Limitations and future research directions

The conducted SLR has several limitations: an empirical research limitation, database sources, keywords, open access articles, and the exclusion of predatory journals. These restrictions were used as part of a deliberate process with an overriding goal of attention to detail and adherence to scientific standards. The study focuses on theoretical research, which serves as preparation for empirical research in the next stage. The SLR provides a solid theoretical foundation and identifies research gaps, enhancing credibility and enabling the more effective planning and implementation of empirical research in the future, increasing its usefulness in practical scenarios. Although the literature review is limited to two databases, Scopus and Web of Science, they are among the most reputable and widely recognised scientific databases available. The selected keywords potentially limit the scope of the study but help to keep the literature review and data collection process exclusively relevant to the main topic of the study, thus avoiding the inclusion of unrelated information. The restriction applied in this study related to the use of papers from open access is intended to promote the democratisation of access to scientific knowledge. The elimination of literature sourced from predatory journals is intended to reassure the scientific community that the data used for analysis come from sources whose quality and ethical values of the selection process are beyond doubt.

The study results justify the need for empirical research to verify the relevance of the various areas of sustainability occurring in the digital transformation process. Nevertheless, to do that, there is a need to diagnose what the impact factors are in each area of sustainability when implementing the sustainable digital transformation process, and how they interact with each other. In the view of the authors, these results are an excellent initial step towards developing an enterprise digital transformation strategy based on sustainable factors. Among the articles reviewed, a number of definitions were identified that, at a high level of generality, are similar when it comes to the vision and fact of combining sustainability with digital transformation in a single process. However, these definitions differ at the operational level of the process. The current research suggests that a sustainable digital transformation approach could be used to implement digital changes in an organisation in a way that is beneficial for the organisation and all the stakeholders involved. Further research is needed to identify a uniform definition and assumptions for this process. Additionally, the table (Table 4) includes two additional streams that are worth deepening: Problem 2 on the parameterisation of sustainability in the digital transformation process and Problem 3 on the implementation of a sustainable digital transformation in organisations.

Tab. 4. Further research proposition

Potential future theoretical developments	Potential future empirical investigations	Potential research questions
Problem 1: A uniform definition of sustainable digital transformation is lacking.		
• constructing a new definition of sustainable digital transformation • reconsidering existing theories used in the process of digital transformation	• testing the understanding of the definition of sustainable digital transformation • comparative analysis of existing definitions by experts	• To what extent does the definition reflect the process of sustainable digital transformation? • What are stakeholders' attitudes towards the transformation process after learning its definition?
Problem 2: Companies struggle to parameterise the impact of sustainability in the digital transformation process.		
• exploring the areas of sustainable digital transformation in terms of characteristics • determining factors in each of the identified individual areas • theorising the level of relevance of different areas of sustainable digital transformation	• examining the correlation between the impacts of factors in the areas of sustainable digital transformation • exploring potential paradoxes between areas	• How can the results of the parameterisation of the sustainable digital transformation process be interpreted? • To what extent are the different areas of sustainable digital transformation relevant?
Problem 3: Lack of a uniform implementation of sustainable digital transformation in organisations.		
• theorising the positive and negative effects of the sustainable digital transformation process • theorising the role of different stakeholders in organisations before, during and after the process of sustainable digital transformation	• testing whether one framework can be applied to different industries with positive results • showing the consequences of sustainable and unsustainable digital transformation processes	• How can the process of sustainable digital transformation be conducted? • What should the evaluation process look like?

The proposed research directions offer a complementary blend of focused theoretical and empirical investigations, contributing to research rigour and quality. From the perspective of the parameterisation of the concept, it would be beneficial to place particular emphasis on the empirical dimension of the research, while still acknowledging the importance of theoretical foundations. The outlined research paths have the potential to shape a new approach to digital implementation, positioning sustainability concerns as the primary point of departure.

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