Artificial intelligence automation, augmentation, and human-centricity for firm resilience [1] [2]

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Abstract

Frame of the research. *Rapid advancements in artificial intelligence (AI) have fundamentally transformed how firms create and deliver value. Simultaneously, recent decades have been marked by an increasing frequency and severity of exogenous shocks; accordingly, management literature has emphasized firm resilience as a key meta-capability for firm survival. Given that AI can shape how firms sense and respond to uncertainty, it is plausible that it also plays a role in shaping firm resilience.*

Purpose of the paper. *This paper aims to investigate how AI and human intelligence shape the development of firm resilience.*

Methodology*. We develop a conceptual framework that integrates the automation and augmentation approaches to AI with established resilience micro-capabilities: redundancy, robustness, agility, flexibility, adaptability, and resourcefulness. Adopting a dialectical approach, we analyze the interrelation between AI and human intelligence in the development of these micro-capabilities.*

Results*. We identify three interrelated spaces (i.e., automation, augmentation, and human-centricity) for the development of firm resilience micro-capabilities. Automation primarily supports redundancy and robustness; augmentation enables agility, flexibility, and adaptability; and resourcefulness is grounded in human-centricity. The framework also elucidates how these spaces contribute to both absorptive and adaptive resilience.*

Research limitations. *The conceptual nature of this study calls for future empirical corroboration.*

Managerial implications. *This study provides managers with a conceptual map to guide the strategic orchestration of human and AI resources in building firm resilience.*

Originality of the paper. *This paper offers a novel and integrative perspective on firm resilience by linking AI and human intelligence to firm resilience micro-capabilities. By adopting a dialectical approach of automation, augmentation, and human-centricity, it advances current understandings of how AI can be leveraged as a foundational enabler of firm resilience.*

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1. Introduction

The advent of artificial intelligence (AI) is revolutionizing the business landscape by driving a transformative shift that reshapes industries, redefines how value is created within firms (Gama and Magistretti, 2023; Aagaard and Tucci, 2024; Chatterji *et al.*, 2026), and influences their sustainability (Lanfranchi *et al.*, 2025). AI can process enormous amounts of data and transform them into information (Prasetyo *et al.*, 2025) with a level of precision and speed that far surpasses human capabilities (Krakowski *et al.*, 2023).

Over the past decades, firm resilience has gained prominence in business studies due to unpredictable, high-impact exogenous shocks (Williams *et al.*, 2017). The well-being of shareholders, employees, and entire territories is closely linked to firms' ability to absorb and adapt to such shocks (Lengnick-Hall *et al.*, 2011; Kahn *et al.*, 2013, 2018). Accordingly, the literature has extensively focused on identifying the factors that make some firms more resilient than others (Carmeli and Markman, 2011). Furthermore, scholars have identified the key micro-capabilities underlying firm resilience: redundancy, robustness, agility, flexibility, adaptability, and resourcefulness (Conz and Magnani, 2020).

Studies have begun to bridge the literature on AI and resilience, primarily focusing on AI as an enabler of supply chain resilience (Iftikhar *et al.*, 2024; Ismail *et al.*, 2025; Dai and Zhang, 2026) or human resource resilience (Panda *et al.*, 2024). However, framing AI and human intelligence merely as a dichotomy may lead to misleading conclusions (Raisch and Krakowski, 2021; Shepherd and Majchrzak, 2022). Greater attention should instead be devoted to augmentation, grounded in the synergies between AI and human intelligence (e.g., moving from Kemp, 2024, who proposes a framework for developing competitive advantage). Both AI and human intelligence can be conceptualized as key drivers of organizational action and decision-making (Nauhaus *et al.*, 2021; Raisch and Krakowski, 2021), which are central to resilience micro-capabilities (Conz and Magnani, 2020).

The lack of clarity on how AI and human intelligence jointly shape firm resilience at the micro-capability level warrants attention for two reasons. First, given the inexorable diffusion of AI, a deeper understanding of its impact on firm resilience can support more informed and effective integration of AI into organizational processes. Second, in light of the increasing frequency and inevitability of exogenous shocks, it is essential to disentangle the roles of AI and human intelligence in enabling firm resilience. Accordingly, we formulate the following research question:

RQ: *How do AI and human intelligence interrelate to shape the development of firm resilience micro-capabilities?*

AI may serve as a "milestone," fundamentally reshaping each firm resilience micro-capability to better face adverse conditions. Accordingly, this study examines how AI and human intelligence impact the six key micro-capabilities underpinning firm resilience.

We adopt a dialectical approach to unpack the role of AI in the development of resilience (Smith and Lewis, 2011), examining both automation and augmentation. In the *automation* approach, machines perform tasks previously accomplished by humans (Raisch and Krakowski, 2021). By contrast, *augmentation* involves humans collaborating closely with machines to complete tasks (Raisch and Krakowski, 2021). The output generated by machines becomes input for human activities, which in turn feed back into machines in an iterative process until interrupted by human intervention. However, in some cases, the role of human intelligence in creativity, intuition, and emotional insight remains central (Goleman, 1995).

Based on a conceptual investigation, our framework elucidates AI's role via automation in fostering redundancy and robustness; reveals the role of AI via an augmentation approach in enabling flexibility, agility, and adaptability; and emphasizes the role of human intelligence in driving resourcefulness.

This study makes three key contributions. First, we advance AI research by examining the impact of AI and human intelligence on firm resilience through the dual lenses of automation and augmentation (Raisch and Krakowski, 2021). Drawing on Ketchen *et al.* (2007), we emphasize that AI's value remains potential high only when complemented by human intelligence. We enrich the debate on AI as both a "player and a coach" of firm capabilities and of the antecedents of resilience in particular.

Second, we contribute to the literature on resilience by arguing that AI can help firms mitigate exogenous shocks and navigate the *permacrisis* age (Brown *et al.*, 2023; Conz *et al.*, 2026). We offer an innovative perspective on the antecedents of firm resilience, complementing existing multi-level and multi-theoretical approaches (Aversa *et al.*, 2024).

Third, we highlight the possible interrelation of three spaces (automation, augmentation, and human-centricity) in the development of firm resilience and identify the mechanisms that shift the balance among these spaces in response to change and the permacrisis.

The remainder of this paper is organized as follows. First, we review the literature on AI and firm resilience. Next, we present a conceptual framework illustrating the role of AI and human intelligence in shaping the six core micro-capabilities driving firm resilience (Conz and Magnani, 2020). Subsequently, we discuss the mechanisms underlying the interrelations among the automation, augmentation, and human-centric spaces in shaping firm resilience. The paper concludes with a discussion and potential directions for future research.

2. Literature background

2.1 Artificial intelligence: An overview

AI employs various techniques, such as machine learning, neural networks, and deep learning (LeCun *et al.*, 2015; Haenlein and Kaplan, 2019; Aggarwal, 2023). *Machine learning* focuses on teaching machines to learn from data by developing algorithms that uncover patterns and make predictions (Choi *et al.*, 2020). *Neural networks* are "machine learning techniques that simulate the mechanism of learning in biological organisms" (Aggarwal, 2023, p. 1). While learning in biological organisms relies on external stimuli, in artificial neural networks these stimuli come from training data (Aggarwal, 2023). *Deep learning* has proven effective in uncovering complex structures within data, enabling models to recognize patterns and extract meaningful features without explicit human guidance (LeCun *et al.*, 2015). More precisely, deep learning is a category of machine learning that uses neural networks. It is characterized by "depth," which refers to the large number of hidden layers among the input and output layers of the network (Haenlein and Kaplan, 2019; Secchi, 2022).

Furthermore, a new form of AI, distinct from traditional AI, is gaining increasing importance: *Generative AI* (GenAI). Whereas traditional AI systems are primarily utilized for data analysis and predictive modeling, GenAI goes further by generating new data that closely resemble the characteristics of the training set (Aagaard and Tucci, 2024). GenAI is considered "a form of AI that can drive innovation through new product discovery and development" (Mariani and Dwivedi, 2024, p. 1)[3]. OpenAI's introduction of Generative Pre-trained Transformers (GPT) marked a significant advancement in natural language processing (NLP). GPT progressively pushes the limits of AI capabilities, enabling the performance of tasks traditionally considered uniquely human (Marcus and Davis, 2020). By aggregating evaluations between LLMs and prompts, managers may harness GenAI to provide useful insights for strategic decisions (Doshi *et al.*, 2025). Additionally, GenAI may boost firm performance although the effect of its adoption is moderated by ethical leadership (Kumar *et al.*, 2025).

[3] Building on deep learning and neural network architectures, natural language processing (NLP) and large language models (LLMs) have emerged as key approaches for language-related tasks (Doshi *et al.*, 2025). Natural language processing (NLP) is a branch of AI "in which computer machines can analyze and interpret human speech for human-computer interaction (HCI) to generate structural knowledge for information retrieval operations, text and automatic text summarization, sentiment and speech recognition analysis, […] at different levels of Q&A chatbots" (Lee, 2025, p. 11). A major advancement in NLP emerged with the introduction of the Transformer architecture (Vaswani *et al.*, 2017), which laid the foundation for the development of LLMs (Zhou, 2025). LLMs are defined as models that "predict the next word based on past statistical patterns" (Chatterji *et al.*, 2026, p. 7). The label "large" reflects the enormous number of parameters embedded in these models, potentially exceeding one trillion (Doshi *et al.*, 2025). Large language training is based on an enormous amount of data, and these models display emergent capabilities, such as the ability to address novel questions (Wei *et al.*, 2022).

2.2 Managing artificial intelligence

AI has become pervasive in the daily lives of both firms and individuals, affecting domains such as smart homes, healthcare, and safety (Stone *et al.*, 2016; Rahwan *et al.*, 2019; Kaplan and Haenlein, 2020). This disruptive innovation has rendered certain business models obsolete (Berente *et al.*, 2021) while creating opportunities to develop novel and more effective solutions to meet human needs, thereby generating new business opportunities (Agrawal *et al.*, 2018; Townsend and Hunt, 2019; Davenport *et al.*, 2020). It is therefore not surprising that AI is revolutionizing several industries (Wilson and Daugherty, 2018), permeating virtually all activities within Porter's value chain across many firms (Kolbjørnsrud *et al.*, 2016), and redefining how value is created and distributed both within organizations (Haefner *et al.*, 2021) and across their ecosystems (Aagaard and Tucci, 2024). Furthermore, AI is transforming customer relationship management (CRM) from a data-driven approach to an AI-driven strategy (Ledro *et al.*, 2022).

Within this broader transformation, recent studies have begun to examine AI's implications for management, particularly in human resource management (HRM), where AI enables the integration of new capabilities into organizational practices, further highlighting its managerial relevance (Tambe *et al.*, 2019; Laviola *et al.*, 2024). Broadly, AI can be leveraged to enhance key HRM processes, including employee selection and training (Tambe *et al.*, 2019). Some scholars have also conceptualized AI as a "coach" for workers and managers, defined as "a machine-assisted, systematic process to help clients set professional goals and construct solutions to efficiently achieve them" (Graßmann and Schermuly, 2021, p. 109).

Human intelligence relies on heuristics to process information, which can lead to distortions and errors, often referred to as cognitive biases (Krakowski *et al.*, 2023). Concurrently, it embodies boundless creativity, intuition, and emotional intelligence (Goleman, 1995). Pivotal AI capabilities include "data pipeline capability" and algorithm development capability (Sjödin *et al.*, 2021, p. 578; Shrestha *et al.*, 2021). AI and human intelligence appear to be oriented toward different activities and are distinguished by their unique strengths and weaknesses (Krakowski *et al.*, 2023; Raisch and Fomina, 2025; for a review see Ramaul *et al.*, 2026). Thus, understanding their distinct strengths, limitations, and interrelations is crucial for both scholars and practitioners.

Scholars have identified two main approaches to exploring AI's role in strategy. The first is the *automation* approach, which heightens the tension between AI and human intelligence rather than exploring areas of integration. This approach places human intelligence and AI in an "either/or" relationship, where broader AI adoption corresponds to a diminished role for human intelligence within a firm. Thus, the automation approach is conceptually built on the tensions between humans and AI rather than their collaboration. This tension reaches its apex when automation is no longer perceived as a complementary tool to enhance human capabilities but as an approach designed solely to supplant human workers.

The second is the *augmentation approach*, which manages the tension between AI and human intelligence as a trigger for a new attitude rooted in a "both/and" relationship (Raisch and Krakowski, 2021). In today's competitive context, relying on AI solely for automation reflects an outdated approach that is unsuitable for navigating high levels of uncertainty. Consequently, firms face higher risks of imitation and increased vulnerability (Raisch and Krakowski, 2021). By contrast, augmentation combines the strengths of both humans and AI (Raisch and Krakowski, 2021).

We argue that the coexistence of AI and human intelligence follows a Hegelian dialectical approach to their relationship. Dialectics resolves contradictory elements (thesis and antithesis) through synthesis. The *thesis-antithesis-synthesis* movement represents a process of knowledge progression in which each synthesis becomes a new thesis, is confronted by an antithesis, and is resolved into a further synthesis in a continuous spiral. Following this reasoning, we conceptualize the augmentation of AI and human intelligence as Hegelian *Aufhebung*, that is, the moment of synthesis that unifies thesis and antithesis.

AI and human intelligence are "both contradictory and interrelated" (Smith and Lewis, 2011, p. 387). Given their interrelated nature, we adopt a dialectical approach (Smith and Lewis, 2011) to address underlying paradoxical (Raisch and Krakowski, 2021) and dialectical tensions. Specifically, "integration is temporary" (Smith and Lewis, 2011, p. 387), culminating in a continuous interrelation.

To augment human intelligence with AI, humans must understand "where, when, and how to best utilize" AI efficiently (Robertson *et al.*, 2024, p. 499). In this regard, augmentation holds paramount significance, as human cognitive processes extend beyond mere data collection and processing; they are also shaped by what Carl Jung referred to as intuitive intelligence (Jarrahi, 2018). Accordingly, it is now widely accepted that human reasoning is not purely a conscious or deliberate process. Modern cognitive science posits that a significant portion of human cognition, including many higher-level cognitive functions, operates unconsciously (Hodgkinson *et al.*, 2009).

In this context, it is essential to distinguish intuitive intelligence from instinct. Intuitive intelligence is closely tied to "intuition," that is, "thoughts, conclusions and choices produced largely or in part through non-conscious mental processes" (Hodgkinson *et al.*, 2009, p. 280). By contrast, instinct refers to innate, reflex reactions (Hodgkinson *et al.*, 2009). In summary, accounting for elements of human intelligence, such as intuitive intelligence (Jarrahi, 2018) and cognitive styles (e.g., adaptors and innovators; Kirton, 1976), is crucial for augmentation, as "tailoring human-AI interaction to individuals' cognitive needs enables performance gains" (Krakowski *et al.*, 2026, p. 69).

2.3 Firm resilience

Resilience enables firms to address unpredictable exogenous events (Taleb, 2010) and moments of discontinuity in their lifecycle that can

undermine performance or survival (Ramezani and Camarinha-Matos, 2020). Wars, pestilences, earthquakes, and hurricanes have shaped human history, both in the past and present (Bouncken *et al.*, 2022). Consequently, firms must develop resilience capabilities to handle continuous challenges (Kantur and İşeri-Say, 2012; Hillmann, 2021; Su and Junge, 2023). Furthermore, ongoing globalization, coupled with institutional, demand, and technological uncertainties, makes firms even more vulnerable (Dagnino *et al.*, 2021). To survive in a state of perpetual crisis, known as *permacrisis*, firms must exercise their resilience capabilities (Brown *et al.*, 2023; Conz *et al.*, 2026).

Scholars have devoted significant attention to resilience, offering various definitions across theoretical perspectives and disciplines (Conz and Magnani, 2020; Aversa et al., 2024). Extant literature emphasizes the *contextual* nature of resilience (Lengnick-Hall *et al.*, 2011) and highlights the variety of organizational responses across different phases of exogenous events (Martinelli *et al.*, 2021). Specifically, studies have identified multiple antecedents of resilience, including entrepreneurs' psychological factors (Williams *et al.*, 2021), individual resilience (Martinelli and Tagliazzucchi, 2019; Giaccone and Picone, 2026), firm characteristics (Hillmann and Guenther, 2021; Su and Junge, 2023), and supply chain contributions (Pal *et al.*, 2024).

Summarizing prior literature, Hepfer and Lawrence (2022, p. 15) describe strategic resilience as a firm's "ability to anticipate and respond to threats to its strategy, and especially its long-term goals." Accordingly, the literature distinguishes between two types of resilience: proactive and reactive. *Proactive* resilience reflects a firm's readiness in times of adversity and embodies the sensitivity of its organizational "epidermis," enabling early detection of potential disruptions (Williams *et al.*, 2017). Strengthening this sensitivity requires providing firms with the tools needed to implement anticipation strategies for managing unforeseen events (Williams *et al.*, 2017). Proactive resilience enhances awareness of vulnerabilities and potential threats, thereby facilitating the adoption of proactive strategies (Erol *et al.*, 2010). Temporally, proactive resilience occurs before an event materializes (Duchek, 2020). Therefore, it plays a crucial role in mitigating the consequences of disruptive events by anticipating them (i.e., acting *ex-ante*). For example, a retail firm demonstrates proactive resilience if it anticipates shifts in consumer preferences or invests in slack resources, thereby foreseeing disruptive changes.

By contrast, *reactive* resilience becomes essential when a firm must address the consequences of a disruption ex-post (Boin and Van Eeten, 2013). For instance, firms in the travel and tourism industry demonstrated reactive resilience in response to COVID-19 disruptions. Although they initially experienced a decline in performance, they recovered successfully (Munoz *et al.*, 2022).

Additionally, scholars have distinguished between absorptive and adaptive resilience (Hepfer and Lawrence, 2022). *Absorptive* resilience refers to a firm's capability to mitigate new exogenous conditions, emphasizing its ability to withstand external changes (Kahn *et al.*, 2018). This concept is rooted in early mechanical engineering studies (Rankine,

1867). Absorptive resilience facilitates the restoration of the *status quo ante* and minimizes the negative consequences of shocks (Kahn *et al.*, 2013). For example, a firm with absorptive resilience possesses financial redundancies that enable it to absorb shocks and limit performance decline following a disruptive event.

Adaptive resilience highlights responses to new exogenous conditions by adopting an ecological perspective (Holling, 1973). It refers to the capability to adjust and undergo metamorphosis in response to disruptions, thereby achieving multiple new equilibria (Morais-Storz and Nguyen, 2018). Hence, firms demonstrating adaptive resilience change their business model in response to disruptions, leveraging new technologies or consumer trends to evolve operations and ensure long-term sustainability. Firms may adopt either absorptive or adaptive resilience in response to disruptions, as both strategies are equally effective (Conz and Magnani, 2020).

Since resilience is a multifaceted and multidimensional meta-capability, investigating the relationship between AI and firm resilience requires identifying the core micro-capabilities that constitute resilience. Among various taxonomies, the one proposed by Conz and Magnani (2020) is the most relevant, as it facilitates a comprehensive exploration of these micro-capabilities. This taxonomy distinguishes six core capabilities of firms' resilience:

i. *Redundancy* refers to the micro-capability to keep "some resources in reserve to be used in case of a disruption" passively (Sheffi and Rice, 2005, p. 44).
ii. *Robustness* refers to the micro-capability to absorb negative consequences of disruptive events without sustaining any damage (Erol *et al.*, 2010) or by minimizing potential harm (Kantur and İşeri-Say, 2012). It relies on the deliberate use of excess resources (namely, redundancy) "to withstand pressure on performance and remain insensitive to disruption" (Munoz *et al.*, 2022, p. 183).
iii. *Agility* refers to the micro-capability to respond to emerging turbulence by overcoming obstacles (Ismail *et al.*, 2011), while demonstrating strategic sensitivity (Doz and Kosonen, 2008).
iv. *Flexibility* refers to the micro-capability to learn quickly and adjust plans in response to shifts (Pal *et al.*, 2014). It enables a firm to change strategies rapidly. Specifically, we focus on strategic flexibility, defined as the timeliness of decision-making processes (Pal *et al.*, 2014).
v. *Adaptability* refers to the micro-capability to adjust promptly and effectively in response to disruptions.
vi. *Resourcefulness* refers to the micro-capability to actively harness and orchestrate resources creatively to capitalize on opportunities and address challenges (Williams *et al.*, 2021).

Redundancy and robustness are absorptive resilience capabilities because they primarily focus on withstanding and buffering the consequences of disruptive events without involving change or evolution. Meanwhile, adaptability and flexibility are adaptive resilience capabilities (Conz and Magnani, 2020) that enable firms to change in response to disruptive exogenous events. Most literature considers agility as an

absorptive resilience capability (Conz and Magnani, 2020). However, within our conceptual framework, agility is both absorptive and adaptive, as it enables firms to swiftly overcome obstacles in response to changes in demand or technology (Dagnino *et al.*, 2021). Resourcefulness stands out as an adaptive micro-capability that facilitates both adaptation and metamorphosis. Conz and Magnani (2020) define resourcefulness as "the capability to accumulate different diversified assets and resources" (p. 409) and at the same time, creatively utilize resources (Williams *et al.*, 2021).

3. Toward a conceptual framework: Harnessing human and artificial intelligence for firm resilience

The development of firm resilience micro-capabilities is inextricably shaped by intelligence, derived from the Latin *intelligentia* (Castiglioni and Mariotti, 1996), which evokes the capability to discern, comprehend, and effectively navigate changes. Our framework considers two forms of intelligence: human and artificial. Therefore, it is essential for firms to manage the interrelated spaces of automation, augmentation, and human-centricity concurrently to develop the core micro-capabilities underpinning firm resilience (Conz and Magnani, 2020).

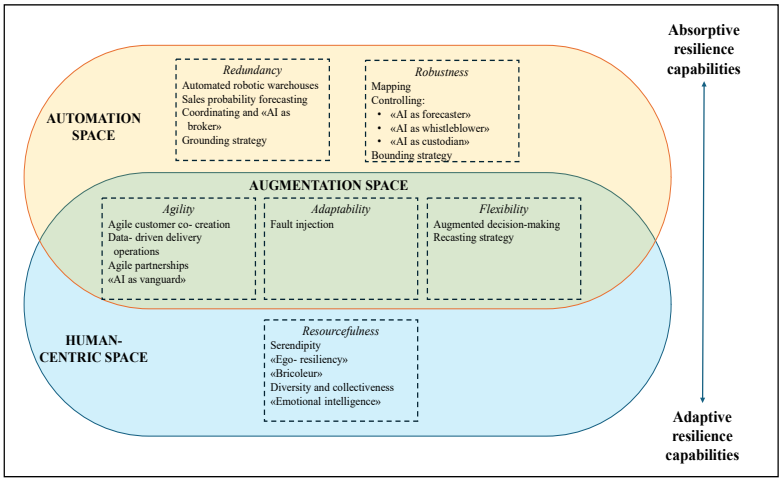
Fig. 1 presents our conceptual framework. We theorize the impact of AI on each core micro-capability underlying firm resilience. We contend that human-centricity remains a core factor in fostering firms' resilience micro-capabilities, such as resourcefulness. In parallel, we conceptualize redundancy and robustness in the automation space, where machines take over tasks previously performed by humans (Raisch and Krakowski, 2021), while humans' roles remain primarily situated upstream in training AI algorithms (Sjödin *et al.*, 2021). The augmentation space concerns the development of agility, flexibility, and adaptability (Raisch and Krakowski, 2021). Indeed, "automation may be suitable for routine tasks" (Krakowski *et al.*, 2026, p. 68), while exploratory tasks (e.g., solving new problems; Raisch and Fomina, 2025) require both human intelligence and AI. Arguably, the three spaces (automation, augmentation, and human-centricity) are not independent; rather, they may be dynamically interrelated.

3.1 Resilience micro-capabilities in the automation space

3.1.1 Redundancy

The literature shows that firm resilience requires slack resources (Conz *et al.*, 2023), particularly redundancies. Redundancy refers to keeping reserve resources available for use in case of disruption (Sheffi and Rice, 2005). These resources may have latent functionality that becomes fully evident in adverse situations (Munoz *et al.*, 2022), thereby serving their risk-protection role. This latent functionality highlights the tension between resilience and financial performance (Iftikhar *et al.*, 2021), which stems in part from the trade-off between redundancy and efficiency.

Fig. 1: Conceptual framework:
Harnessing AI and human intelligence for firm resilience



Source: Authors' elaboration

Firm efficiency is achieved primarily by minimizing resources (e.g., inventory, financial resources). For instance, Just-in-Time (JIT) models exemplify efficiency: "the reason for the adoption of JIT was to make the facility more efficient and reactive to the product-market environment," primarily through inventory reduction (Huson and Nanda, 1995, p. 305). Redundancy relies on the availability of slack resources (Conz *et al.*, 2023), whereas efficiency depends on minimizing resource deployment within firms. Consequently, a fundamental trade-off exists between the two concepts.

Hence, firms must carefully navigate this inherent tension as building redundancy remains essential for absorbing the negative impacts of disruptions. This typically involves holding additional financial resources, sustaining inventory stocks, and/or maintaining relationships with secondary suppliers, each of which entails significant costs (Sheffi and Rice, 2005). Consequently, redundancy often leads to increased costs and potential inefficiencies, despite its value in enhancing firm resilience.

The literature identifies a strong positive relationship between firm resilience and non-financial performance (Yu *et al.*, 2019; Iftikhar *et al.*, 2021). Resilience enhances operational performance, creates customer value, and supports competitive advantage (Chowdhury and Quaddus, 2016). The literature finds a weaker positive relationship between firm resilience and financial performance (Yu *et al.*, 2019; Iftikhar *et al.*, 2021), suggesting that investments in resilience may incur financial penalties (Yu *et al.*, 2019). The role of AI in enhancing efficiency is widely acknowledged in the literature, highlighting its potential to generate significant cost reductions and efficiency gains (Mariani *et al.*, 2023).

Building on these insights, we suggest that AI helps mitigate the tension between firm resilience and financial performance by addressing the

trade-off between efficiency and redundancy. Specifically, AI capabilities contribute to redundancy by enabling firms to define the optimal balance between redundancy and efficiency.

AI is useful in mapping areas within firms that underutilize resources to enhance efficiency (Mariani *et al.*, 2023). For example, an "automated robotic warehouse" allows real-time inventory tracking and control. Therefore, AI is valuable for optimizing inventory control and logistics (Aagaard and Tucci, 2024) by enhancing efficiency (Shil *et al.*, 2024). Accordingly, it becomes appropriate to shift from a "traditional warehouse" to an "automated robotic warehouse" (Aagaard and Tucci, 2024). AI's application in demand forecasting and planning (Lolli *et al.*, 2019), as well as inventory management, helps reduce stockout days and increase inventory turnover rates (Cantini *et al.*, 2024) by identifying the level of redundancy that makes a firm both resilient and efficient.

Moreover, the relevance of AI in enhancing firm resilience extends beyond logistics and warehouses; it also strengthens security and enables monitoring of a firm's "financial health," particularly regarding financial redundancy (Ramezani and Camarinha-Matos, 2020). By contributing to monitoring financial health, AI can guide firms in maintaining the appropriate level of financial redundancy in the face of uncertainty.

AI employs analytical capabilities to process data and uncover relationships useful for forecasting, such as predicting sales probabilities (Reddy Vangoor *et al.*, 2024). Accordingly, it serves as an "information tool to anticipate changes in demand" (Broekhuizen *et al.*, 2023, p. 3) and plays a proactive role in developing redundancy. In particular, AI enables autonomous data processing, including data gathered through advanced sensors and equipment. AI's application in forecasting sales probabilities (Reddy Vangoor *et al.*, 2024) can achieve a synthesis between efficiency models and redundancy, while also mitigating the trade-off between them.

By leveraging AI, firms can define reserves and excess resources within the automation space. This role is facilitated by AI as a "broker" that can enhance "supply chain management by assisting firms in effectively allocating resources" (Broekhuizen *et al.*, 2023, p. 7). AI enhances efficiency and facilitates the coordination and integration of diverse partners, such as supply chain management, through predictive models (Shil *et al.*, 2024).

Moreover, algorithm development capability (Sjödin *et al.*, 2021; Shrestha *et al.*, 2021) enables the creation and reconfiguration of contextualized AI anchored in a firm's unique knowledge through a "grounding" strategy (Kemp, 2024).

However, it is essential to recognize the limitations of forecasting models that utilize AI. They rely on past data to predict future trends, which introduces potential biases (Krakowski *et al.*, 2023).

Overall, we recognize the critical role of AI in automating redundancy development through several mechanisms: automated robotic warehouses (Aagaard and Tucci, 2024); sales probability forecasting (Reddy Vangoor *et al.*, 2024); efficient resource allocation through AI as a "broker" (Broekhuizen *et al.*, 2023); and "grounding" strategies (Kemp, 2024).

3.1.2 Robustness

Previous studies agree that robustness[4] represents a micro-capability of firm resilience (Conz and Magnani, 2020) that supports minimizing the negative consequences of disruptive events and uncertainty. AI affects robustness by enabling firms to anticipate and address risks, for example, by serving as a forecasting tool (Agrawal *et al.*, 2018). The development of robustness is linked to AI primarily through its mapping and controlling functions (Broekhuizen *et al.*, 2023).

The mapping function facilitates scanning internal and external environments and addressing issues by analyzing extensive databases to identify firms' weaknesses and external threats (Broekhuizen *et al.*, 2023).

However, the controlling function facilitates the detection of anomalies and anticipation of potentially detrimental consequences (Broekhuizen *et al.*, 2023). This enables the implementation of preventive strategies aimed at minimizing response times (Erol *et al.*, 2010) and supporting proactive resilience. This function enhances robustness by leveraging AI acting as a "forecaster," "whistleblower," and "custodian" of knowledge (Broekhuizen *et al.*, 2023, p. 5), in conjunction with a "bounding" strategy (Kemp, 2024).

i. AI as a "forecaster" refers to its predictive capabilities. Notably, a decrease in prediction costs (Agrawal *et al.*, 2018) enables firms to explore alternative scenarios through proactive simulations, which play a central role in identifying potential futures and detecting obstacles (Kelleher *et al.*, 2020). By providing environmental, technological, competitive, and supply chain information, AI can help anticipate and prevent disruptive events (Zong and Guan, 2025), thereby enhancing robustness.

ii. AI as a "whistleblower" allows firms to implement rapid warning systems (Broekhuizen *et al.*, 2023). For example, AI can perform sentiment analysis (Bouschery *et al.*, 2023) to "analyze inter-partner communication or negative customer feedback to detect negative sentiments" (Broekhuizen *et al.*, 2023, p. 6).

iii. AI as a "custodian" of knowledge protects and strengthens firms when combined with a "bounding" strategy (Kemp, 2024). Both AI as a "custodian" of knowledge (Broekhuizen *et al.*, 2023) and the "bounding" strategy aim to counter the notion of AI as merely explicit knowledge (Kemp, 2024). AI as a "custodian" monitors and prevents intellectual property violations, especially in open innovation (Broekhuizen *et al.*, 2023). The "bounding" strategy further enhances robustness through encryption, cybersecurity measures, and confidentiality agreements with suppliers, employees, and coopetitors (Kemp, 2024).

[4] Robustness can be conceptualized in two ways, either as a distinct capability that enables the complete avoidance of performance degradation during disruptive events (Munoz *et al.*, 2022), or as an intrinsic micro-capability within the broader construct of firm resilience (Kantur and İşeri-Say, 2012), which helps minimize such degradation. In our study, we adopt the latter view, framing robustness as a micro-level firm resilience capability.

3.2 Firm resilience micro-capabilities in the augmentation space

3.2.1 Agility

We adopt the definition of agility as a firm's capability to swiftly respond to emerging turbulence by overcoming obstacles (Ismail *et al.*, 2011) while demonstrating strategic sensitivity (Doz and Kosonen, 2008). To develop agility, AI augments the human capability to predict (Zong and Guan, 2025) and manage environmental and social transformations (Minà and Michelini, 2024) using data-driven and customer-oriented managerial approaches.

In today's transformative and uncertain landscape (e.g., demand uncertainty), it is imperative to embrace a "holistic and human-centric approach that addresses the technological, organizational, and strategic facets of AI deployment for enduring success and competitiveness" (Aagaard and Tucci, 2024, p. 303). Accordingly, adopting AI enables a strategic transition "toward data-driven, customer-centric, and flexible business practices," marking a shift to a new era (Aagaard and Tucci, 2024, p. 297).

Specifically, AI predictive capabilities enable a deep understanding of customer preferences, which strengthens agility. For instance, the literature recognizes an archetype of AI application called "experience innovators," which adopt AI to engage and customize products and services, "prioritizing customer-centric AI applications" (Aagaard and Tucci, 2024, p. 307). Thus, if AI tools can identify unmet needs (Lanzolla *et al.*, 2021) or align with customer preferences, they can foster agility.

We account for agile customer co-creation, data-driven delivery operations (Sjödin *et al.*, 2021), agile partnerships, and AI as a "vanguard" (Broekhuizen *et al.*, 2023) as key capabilities and strategies that enable the development of agility.

i. Agile customer co-creation involves adopting the augmentation approach, which extends beyond firm boundaries. Customers and firms iteratively co-create new solutions by leveraging AI (Sjödin *et al.*, 2021). Agility through customer co-creation enables the early deployment of AI microservices even before development and testing are complete, fostering cooperation between firms and customers for final development (Sjödin *et al.*, 2021). This dimension of agility opens new frontiers in human-machine interactions in the context of augmentation, establishing an interactive relationship characterized by transparency and reciprocal exchange beyond firm boundaries. "Agile customer co-creation" allows for the development of new solutions leveraging AI, constituting a key element of cooperation between firms and customers. However, the advent of GenAI makes it imperative to embrace the constant evolution of AI to personalize customer relationships. Therefore, GenAI enables a heightened form of personalization, known as "hyper-personalization," allowing firms to quickly tailor products or services to each customer preferences (Aagaard and Tucci, 2024).

ii. Data-driven delivery operations (Sjödin *et al.*, 2021) involve aligning firms' products and services with customer preferences and processing real-time data through AI to respond promptly to customer needs. These operations are performed using an augmentation approach that involves skilled engineers assessing AI-generated recommendations (Raisch and Krakowski, 2021).
iii. Agile partnerships enable the construction of strategic networks between firms to jointly explore AI opportunities. Co-creation through AI extends beyond customer involvement and can broaden a firm's boundaries to include other actors (Gama and Magistretti, 2023). Agile partnerships can take the form of open innovation, cooperation, or coopetition. To ensure their success, AI can act as a "custodian" to safeguard knowledge and prevent opportunistic behaviors (Broekhuizen *et al.*, 2023).
iv. AI as a "vanguard" may contribute to firm agility by mitigating exposure to demand uncertainty (Broekhuizen *et al.*, 2023). Specifically, it enables the assessment of new business opportunities and monitoring of emerging trends, fostering the dimension of agility known as "strategic sensitivity" (Doz and Kosonen, 2008).

3.2.2 Flexibility

The literature identifies flexibility as a key firm resilience micro-capability, defined as the ability to learn quickly and adjust plans in response to shifts (Pal *et al.*, 2014), thereby enabling firms to change strategies rapidly (Conz and Magnani, 2020). Flexibility also concerns the timeliness of decision-making processes (Pal *et al.*, 2014). This micro-capability is essential in times of high uncertainty, as it allows tempestive judgments and rapid responses to changes (Shimizu and Hitt, 2004).

AI is inherently flexible because it evolves with emerging trends, reconfigures itself to meet diverse user needs, and develops solutions beyond those initially envisaged (Haenlein and Kaplan, 2019). For example, Haenlein and Kaplan (2019) describe AI as a tool that allows firms to learn from existing data and fit flexibly to their environment.

We acknowledge that AI plays a crucial role in enabling flexibility by integrating analytical reasoning and intuitive processes for decision-making (Akinci and Sadler-Smith, 2012; Jarrahi, 2018; Shrestha *et al.*, 2021). AI augments human decision-making capabilities (Chatterji *et al.*, 2026), facilitates new modes of interaction with customers (Wilson and Daugherty, 2018), and enhances creativity and organizational performance (Mikalef and Gupta, 2021). While AI extends human cognition by processing computational information analytically (Shrestha *et al.*, 2021), humans adopt a holistic and intuitive approach to decision-making (Jarrahi, 2018) that transcends mere information, embracing an unconscious yet visionary perspective.

Reasoning, problem-solving, and decision-making have traditionally been viewed as core human cognitive functions (Marcus and Davis, 2020). However, the literature acknowledges that AI can augment these capabilities (Raisch and Krakowski, 2021; Chatterji *et al.*, 2026), supporting flexibility

and human decision-making (Nauhaus *et al.*, 2021). In this context, human intelligence interacts with AI to perform managerial tasks within firms (for a review, see Hillebrand *et al.*, 2025) and GenAI can be leveraged by managers to gain insights into strategic decisions (Doshi *et al.*, 2025).

Developing strategic flexibility also requires a "recasting" strategy, embedding AI "in a firm's system of task, strategic, and relational interdependencies" (Kemp, 2024, p. 8) to align with a firm's strategy and enhance flexibility.

In a real-world context governed by entropy, exclusive reliance on probabilistic and analytical thinking is limiting (Jarrahi, 2018). Similarly, relying solely on intuition and unconscious heuristics risks harm, as intuition is prone to biases and guided by tacit learning from errors and prior experience (Jarrahi, 2018). Analytical decision-making, an attribute of AI, offers faster and higher-quality decisions (Wilson and Daugherty, 2018; Fügener *et al.*, 2022). Nevertheless, despite AI's potential in augmenting decision-making processes, humans seem to remain irreplaceable in decision-making. This irreplaceability is demonstrated by "responsibility" as an inherently human capability (Floridi, 2008) and by the influence of subjective and political factors on rational decisions (Jarrahi, 2018). Managing these factors requires human intelligence, including emotional intelligence (Goleman, 1995), sense-making (Weick *et al.*, 1999), subconscious thinking, empathy, and personality traits that guide intuition (Cable and Judge, 2003).

Overall, the augmentation approach emphasizes the need for a combination of human-related capabilities (e.g., intuition, empathy, and emotional intelligence) and AI strengths. For example, by aggregating evaluations between LLMs and prompts, managers can harness AI to enhance strategic flexibility and inform decision-making (Doshi *et al.*, 2025).

3.2.3 Adaptability

Firm adaptability refers to the micro-capability to adjust promptly and effectively in response to disruptions. While it is inherently tied to the human capability to develop physical, cognitive, and behavioral skills essential for survival and recovery, we argue that a firm's adaptability can be further "augmented" by AI (Raisch and Krakowski, 2021). Specifically, AI supports the development of adaptability through techniques such as fault injection.

Fault injection involves the intentional exposure to errors and induced failures, and contributes to adaptability by equipping firms to respond to similar disruptions in the future (Ramezani and Camarinha-Matos, 2020). Humans interpret fault injection results, develop strategies to address vulnerabilities, and ensure alignment with broader organizational goals, values, and ethical considerations.

By leveraging mechanisms such as fault injection, AI enhances firms' adaptability by complementing human intelligence. In fault injection, humans excel in unstructured situations where ambiguity is intentional, data are incomplete, and creativity and human-machine collaboration are

essential. In this context, human emotions play a critical role in building trust in AI, as humans tend to react more negatively to AI errors than to human mistakes (Fügener *et al.*, 2022). Emotional responses strongly influence perceptions of AI's reliability and effectiveness, making trust inherently fragile. While trust increases when AI demonstrates its capability to enhance firm resilience (e.g., adaptability), it remains vulnerable due to "algorithm aversion" (Fügener *et al.*, 2022). Therefore, fostering trust requires not only showcasing AI's potential to improve adaptability but also addressing emotional barriers that can lead to skepticism and reluctance toward adoption.

Fault injection involves testing unforeseen failures and its proper management it is essential for enabling human-machine collaboration (for a review on human-machine collaboration see Li *et al.*, 2023) in contexts requiring teamwork, and handling sensitive situations.

3.3 Firm resilience micro-capability in the human-centric space

3.3.1 Resourcefulness

Resourcefulness involves the creative orchestration of resources to seize opportunities and overcome obstacles (Williams *et al.*, 2021). By connecting resourcefulness to concepts such as serendipity, "ego resiliency," (Oshio *et al.*, 2018, p. 54), "bricoleur" (Lévi-Strauss, 1966), diversity and collectiveness (Conz and Magnani, 2020), and emotional intelligence (Goleman, 1995), this study emphasizes the indispensable role of human intelligence in cultivating resourcefulness. While primarily rooted in human-centric processes, it enables behaviors that transcend boundaries to generate unplanned sources of value (Williams *et al.*, 2021).

First, resourcefulness can manifest as a firm's ability to improvise and leverage serendipity, particularly under resource constraints (Denrell *et al.*, 2003). As defined by Denrell *et al.* (2003), serendipity emerges from a combination of effort, luck, readiness, and flexibility within a process that precedes unplanned discoveries. Serendipity is triggered by the unexpected, which humans interpret subjectively through processes such as "association" (i.e., the formation of mental connections; Busch, 2024) and "bisociation," which refers to the simultaneous association of objects or ideas typically considered unrelated (Koestler, 1964).

Second, "ego-resiliency" refers to the dynamic capability to temporarily modify one's reactions and perceptions in response to emerging circumstances (Oshio *et al.*, 2018). Individuals with high "ego-resiliency" are enterprising and can adapt to new situations by modifying behavior using versatile cognitive and social strategies (Oshio *et al.*, 2018). In highly stressful situations, such individuals do not act rigidly or repeat mistakes but adjust effectively to challenges (Oshio *et al.*, 2018).

Third, "bricoleur," a term introduced by anthropologist Lévi-Strauss (1966), describes the human capability to leverage available resources to solve problems. It plays a crucial role in creatively utilizing existing resources to generate unplanned value-creating opportunities within the entrepreneurial process (Williams *et al.*, 2021).

Fourth, human diversity within a firm (in terms of gender, ethnicity, and cultural background) enhances creativity, innovation, and resourcefulness (Aggarwal *et al.*, 2019). Collectiveness entails coordination and interaction among individuals, both within and outside a firm, and the promotion of a shared, positive vision that supports creative problem-solving (Conz and Magnani, 2020). Hence, human diversity (Aggarwal *et al.*, 2019) and interaction among individuals within firms foster a shared vision and active participation, contributing to enhanced creative problem-solving (Conz and Magnani, 2020).

Finally, a critical enabler of resourcefulness is a dimension of human intelligence: emotional intelligence, a concept introduced by Goleman (1995). Emotional intelligence is the ability to handle emotions and plays a crucial role in human resilience to stress (Schneider *et al.*, 2013), enhancing the ability to navigate disruptions and crises effectively (Hartmann *et al.*, 2020).

At the current stage of AI development, GenAI can augment human creativity and foster innovation. However, it cannot develop real resourcefulness. Resourcefulness remains closely tied to identity-related human traits, such as empathy, sentiment, emotions, and intuitive and emotional intelligence. Thus, we argue that resourcefulness is rooted in the human-centric space.

4. Potential interrelations among automation, augmentation and human-centric spaces

We build our conceptual framework on a dialectical approach, arguing that AI and human intelligence are "both contradictory and interrelated" (Smith and Lewis, 2011, p. 387). We conceptualize firm resilience micro capabilities as developing within distinct spaces—automation, augmentation, and human-centric—that should not be understood as static or fixed.

Building on this premise, our framework explicates the mechanisms through which these interrelate continuously. While the mechanisms described below are analytically distinct, they do not imply a linear or sequential order; rather, they co-exist and unfold recursively over time. This perspective, represented in Fig. 2, highlights that firm resilience emerges from the ongoing interrelation among automation, augmentation, and human-centric spaces. The underlying mechanisms reshape the relative weights of these spaces, probably without eliminating any. This reflects an ongoing search for a new combination of these spaces in response to both organizational and external changes.

4.1 Interrelations between augmentation and automation spaces

The augmentation and automation spaces interrelate through two mechanisms. Mechanism (A) enables the *reallocation of human time toward higher-order cognitive activities.* Activities initially performed in the augmentation space may become automated over time. For instance,

the development of redundancy and robustness, which initially requires human intervention (e.g., training AI algorithms; Sjödin *et al.*, 2021), can be automated once systems are trained and embedded in organizational processes. Consequently, capabilities developed in the automation space free human time for higher-order cognitive activities (Jarrahi *et al.*, 2023), such as developing of other firm resilience micro-capabilities where human involvement remains essential.

Mechanism (B) concerns *human oversight and monitoring*. It highlights the ongoing need for human validation and recalibration of automated processes. Even when redundancy and robustness develop within the automation space, their effectiveness depends on periodic human intervention. Accordingly, human intelligence remains important in training AI (Sjödin *et al.*, 2021) and monitoring its outputs (Chatterji *et al.*, 2026), ensuring alignment with a firm's evolving strategy (Dagnino *et al.*, 2021).

4.2 Interrelations between augmentation and human-centric spaces

The augmentation and human-centric spaces interrelate through two mechanisms. Mechanism (C) refers to the *improvement of human capabilities through augmentation*. It captures how augmentation enhances human intelligence, particularly through GenAI. While resourcefulness originates in the human-centric space, GenAI supports creativity, ideation, and innovation (Mariani and Dwivedi, 2024). We emphasize these feedback effects, as the development of agility, adaptability, and flexibility in the augmentation space can enhance creativity (Mikalef and Gupta, 2021). In turn, the augmentation space can reinforce the human-centric space.

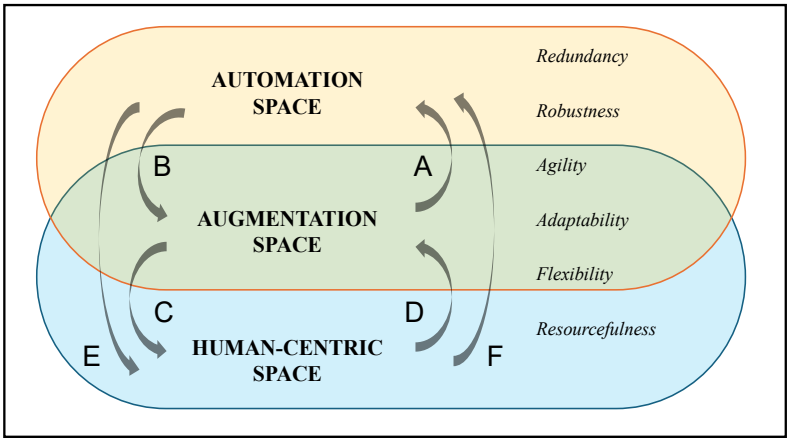
Mechanism (D) involves the *improvement of augmentation through human capabilities*. This dynamic captures how human intelligence enhances augmentation by leveraging human capabilities such as empathy, sentiment, intuition, and emotional intelligence. Thus, the human-centric space reinforces augmentation.

4.3 Interrelations between human-centric and automation spaces

The human-centric and automation spaces interrelate through two mechanisms. Mechanism (E) reflects how the development of resourcefulness in the human-centric space contributes to the *ideation of new processes* aimed at improving firm efficiency through automation. Consequently, the creative orchestration of resources can support the development of redundancy and robustness in the automation space in novel ways.

Mechanism (F) reflects how automation interrelates with the human-centric space by *reallocating cognitive and temporal resources* previously absorbed by routine, data-intensive tasks. As humans are relieved from standardized activities (Jarrahi *et al.*, 2023), they can redirect their efforts toward developing other firm resilience micro-capabilities where human involvement remains essential. In this way, automation indirectly amplifies resourcefulness. This mechanism operates in parallel with Mechanism A.

Fig. 2: Interrelations among the automation, augmentation and human-centric spaces



Source: Authors' elaboration

5. Discussion and conclusion

This study presents a conceptual framework offering a comprehensive understanding of the interrelation between AI and human intelligence within firms for the development of resilience.

5.1 Implications for theory

This study makes three contributions. First, we enrich previous studies on AI by investigating its impact on firm resilience through the dual lenses of automation and augmentation (Raisch and Krakowski, 2021). We argue that robustness and redundancy should develop through automation, as the most valuable resources for value creation within firms are human knowledge, capabilities, and time, which are scarce resources. Accordingly, through mechanisms such as "reallocating human time toward higher-order cognitive activities" and "reallocating cognitive and temporal resources," human intelligence can focus on resilience capabilities that automation cannot currently achieve. Redundancy and robustness should be developed through automation, as these micro-capabilities rely on large datasets and predictive algorithms, areas in which AI outperforms humans (Krakowski *et al.*, 2023).

Therefore, we propose that the development of firms' resilience micro-capabilities should align with the respective strengths of AI and limitations of human intelligence and vice versa. Capabilities based on AI's strengths and human weaknesses (such as redundancy and robustness) should develop in the automation space. Conversely, capabilities rooted in human strengths (such as resourcefulness) and AI's limitations should develop in the human-centric space. This does not imply that these capabilities cannot be augmented. However, developing redundancy and robustness

through augmentation consumes human time, which is a scarce resource. This time-based reasoning applies to the development of redundancy and robustness rather than resourcefulness, which pertains to capabilities currently beyond the reach of AI. Thus, integrating AI into firms requires holistic organizational restructuring (Bresnahan, 2021) and automating activities where human involvement adds little value (Krakowski *et al.*, 2026).

Second, we contribute to the literature on the antecedents of firm resilience by clarifying the role of AI. Specifically, automation, augmentation and human-centricity provide insights into how firms can harness both AI and human intelligence to mitigate exogenous shocks. From this perspective, we complement existing multi-level and multi-theoretical approaches (Aversa *et al.*, 2024). Absorptive resilience micro-capabilities appear more closely associated with automation, while becoming less prominent in the context of augmentation and human-centric spaces. By contrast, adaptive resilience micro-capabilities aligns more with human-centric spaces, particularly regarding how humans and AI interact and complement each other.

Finally, we provide a preliminary contribution to the literature on the interrelations among automation, augmentation, and human-centric spaces, focusing on the emergence of resilience capabilities and the mechanisms that shift the balance among these spaces in response to change and the permacrisis.

5.2 Implications for practice

Our findings offer an actionable guide for managers to leverage AI in navigating major exogenous shocks and the permacrisis age (Brown *et al.*, 2023; Conz *et al.*, 2026). We elucidate AI's role in shaping each key micro-capability underpinning firm resilience (Conz and Magnani, 2020), providing managers with insights into strategically enhancing resilience using AI. Our framework offers a conceptual map to support the effective strategic orchestration of human and AI resources across industries. For instance, in industries where balancing redundancy and efficiency is critical (e.g., the automotive industry), managers can address this trade-off within the AI automation space. Additionally, managers may recognize that AI capabilities (e.g., sales probability forecasts) can help mitigate stockout risks and maintain production continuity, enabling firms to develop redundancies such as safety stock without compromising efficiency.

In industries with high demand uncertainty (e.g., fashion or consumer electronics), managers can foster agility within the augmentation space through AI capabilities such as "agile customer co-creation" (Sjödin *et al.*, 2021) and "AI as a vanguard" (Broekhuizen *et al.*, 2023), allowing firms to respond promptly to changing customer preferences.

Finally, managers should recognize the strategic relevance of human resources marked by resourcefulness and diversity, particularly human capabilities such as ego-resiliency (Oshio *et al.*, 2018) and emotional intelligence (Goleman, 1995), as fundamental enablers of firm resilience.

5.3 Limitations and future research opportunities

This study has several limitations that suggest directions for future research. First, the conceptual framework requires empirical validation to assess its practical implications. Future studies across diverse industries could illustrate how the relationship between AI adoption and firms' resilience micro-capabilities varies. Additionally, future research could empirically examine AI's role in addressing the trade-off between redundancy and efficiency.

Second, our framework assumes AI adoption yields exclusively positive effects. While reasonable, this perspective overlooks the "dark side" of AI (Du and Xie, 2021; Cheng *et al.*, 2022) in the context of firm resilience. AI may be implemented in ways that unintentionally undermine resilience, potentially increasing rather than mitigating firms' vulnerabilities. Future research should empirically investigate whether the use of AI might exacerbate exposure to disruptions under certain conditions. In particular, the relationship between AI adoption and firm resilience could be negative, with AI amplifying risks rather than supporting management.

Third, our framework is tied to the current historical period, and the rapid pace of AI development presents both opportunities and challenges for its future relevance. AI is expected to evolve rapidly, giving rise to new forms of augmentation beyond currently expectations. Advancements in GenAI may expand AI capabilities, enabling more sophisticated human-AI interactions and new decision-making processes that could surpass our current framework. While our framework assumes the interrelation among automation, augmentation, and human-centric spaces, emerging technological trajectories (e.g., advanced human-AI symbiosis; Inga *et al.*, 2023) suggest these boundaries may blur. This aligns with perspectives envisioning hybrid forms of intelligence at cognitive or biological levels (e.g., transhumanism). Consequently, the distinction between the three spaces may become less clear and raises questions about whether resilience will continue to emerge through distinct intelligences or through novel hybrid forms. Additionally, our framework positions resourcefulness within the human-centric space, emphasizing uniquely human capabilities such as emotional intelligence, empathy, and intuition. However, recent AI advancements (particularly NLP) challenge this assumption by enabling machines to simulate and, in some cases, convincingly reproduce empathetic responses. Some studies have highlighted the importance of user perceptions of interactions with voice assistants (e.g., Patrizi *et al.*, 2021). This creates a theoretical tension: if AI can simulate human empathy (e.g., in communication or counseling), the boundary between human-exclusive and machine-augmentable capabilities becomes blurred. Consequently, future research should investigate whether emotional intelligence, empathy, and intuition can be partially or fully simulated by AI and identify related implications for firm resilience.

Fourth, future research could address the dynamic nature of our framework by empirically examining the evolving interrelations among its three spaces. Adopting a longitudinal perspective (e.g., in-depth case studies) would allow scholars to capture how these interrelations unfold

and co-evolve over time, providing a finer-grained understanding of the mechanisms underlying automation, augmentation, and human-centricity in shaping firm resilience.

Finally, our framework assumes that firms deliberately harness AI to build resilience. However, AI may operate as an "invisible" team member, mediating communication and influencing decisions without formal recognition (e.g., employees using AI to write messages intended for colleagues). This introduces a new layer of complexity, as AI may reshape interaction patterns and influence the development of resilience micro-capabilities within hybrid forms of teamwork. Future research should move beyond deliberate AI use and explore how AI as an "invisible" organizational member can affect firm resilience.

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