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Fostering digital trust in manufacturing companies: Exploring the impact of industry 4.0 technologies

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A B S T R A C T

This study examines the multifaceted impacts of digital innovations on organisational structures and stakeholders 'commitment. The integration of digital technologies, including information technologies, IoT, AI, AR/VR, blockchain, robotics, and automation, underscores the indispensable role of trust in contemporary business operations. Focusing on Italian manufacturing firms at the forefront of Industry 4.0 implementation, this research seeks to unravel the nuanced factors contributing to digital trust. A comprehensive framework, derived from an integrative literature review, categorises two distinct groups of factors influencing a firm's decision to establish digital trust. Employing a configurational approach, specifically Qualitative Comparative Analysis (QCA), the joint impacts of multiple factors on digital trust levels are scrutinized, offering insights into how different elements synergise to trigger digital trust. This study aims to bridge existing gaps in understanding the intricate dynamics of trust within organisations undergoing digital transformation.

Introduction

Trust in the adoption of Industry 4.0–enabling technologies, commonly known as digital trust, has become a recent topic of discussion (Lumineau, Schilke & Wang, 2023). Innovations resulting from the fourth industrial revolution are disrupting organisational structure, especially concerning employee sentiments and self-esteem. The use of digital technologies across various business functions, including operations, R&D, finance, marketing, etc., has led to increased information flows and data exchange, necessitating trust-building within the organisation (Ferrario, Loi & Viganò, 2021; Intalar et al., 2021; Rakowska, 2021). Industry 4.0 technologies offer significant innovations that can drastically increase an organisation's productivity (Horváth & Szabó, 2019; Ito et al., 2021). However, the implementation of disruptive changes can give rise to a tense atmosphere within companies, as exclusive dependence on internal resources is not feasible. In this context, the challenge becomes establishing trust among stakeholders (Lumineau et al., 2023). Prior studies stress the need for human-centric approaches that foster trust in individuals and the use of technology for successful cooperation and the attainment of personal and organisational goals (Ettlie, Tucci & Gianiodis, 2017; Lankton, Mcknight & Tripp, 2015; Sindwani, 2022). To this end, organisations are shifting towards integrating Industry 4.0 technologies, moving from human-centric to technology-centric approaches (Mubarak & Petraite, 2020). However, the introduction and diffusion of technologies are accelerating production processes, shortening product life cycles, and driving a faster pace of innovation in companies. For this change to occur, companies must be ready to embrace and value it and define a precise and personalised path based on their characteristics.

The level of trust is a critical factor that influences how employees feel, think, and behave about a specific technological change and is a key component regarding employees' acceptance and adaptation to technology (Bahmanziari, Pearson and Crosby 2003; Smollan, 2013). Especially in the context of digitization, employees' trust in the leadership driving digitization is considered a necessary prerequisite for cooperation and the success of employees in implementing digitization (Van Dam, Oreg & Schyns, 2008; Kotter, 1995; Shah, Irani & Sharif, 2017). As employees must continuously adapt to these changes to keep pace with the evolving work environment (Shah et al., 2017; Ulrich & Yeung, 2019), trust in leadership is a key factor in achieving individual and workplace desirable outcomes (Yunus, Saputra & Muhammad, 2022) such as reducing employees' resistance to change (Vakola, 2014).

Despite growing interest in digital trust related to the introduction of Industry 4.0 technologies, little is known about the factors within an organisation that increase trust levels. Most studies have predominantly focused on the consumer perspective when analyzing digital trust, emphasizing aspects related to online shopping and banking transactions (Al-Debei et al., 2015; Chatterjee et., 2023; Jasiulewicz et.,

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2023; Tul-Krzyszczuk etal., 2024; Vasiliu-Feltes, 2024). These studies typically investigate how consumers develop trust in digital platforms, secure payment systems, and privacy policies, however, there has been significantly less exploration of digital trust from an organizational perspective, particularly within companies. The dynamics of digital trust within a corporate setting are different and more complex because they involve internal stakeholders such as employees, management, and IT departments. This includes understanding how digital trust evolves with the adoption of new technologies, how it impacts employee morale and productivity, and how organizational culture and leadership influence trust levels in digital processes and infrastructure. Shifting the focus to the enterprise context, it is possible to uncover crucial insights into the mechanisms that foster or hinder digital trust in companies undergoing digital transformation. Digital trust encompasses the confidence that stakeholders, including employees, have in the reliability, integrity, and security of digital technologies and the processes associated with them. This trust is crucial because it directly impacts the successful adoption and utilization of these technologies. However, the transition to a digital infrastructure often brings challenges such as fear of obsolescence, resistance to change, and concerns about data privacy and security. These challenges highlight the necessity of building a robust framework of digital trust to facilitate smoother implementation and higher acceptance rates of new technologies.

Therefore, this article seeks to address the gaps in the existing literature by investigating the factors that underlie digital trust. Existing research has primarily focused on digital trust in consumer contexts or specific industries such as finance and e-commerce, leaving a significant gap in understanding how digital trust can be cultivated within organizational settings, particularly in manufacturing sectors. By exploring the unique dynamics of manufacturing firms, this study aims to uncover the specific factors that influence digital trust at various organizational levels. The study is guided by the following research questions:

- What factors influence digital trust?
- How do these factors influence digital trust?

In response to these research questions, a framework is proposed consisting of two distinct groups of factors that can impact the level of digital trust, drawing on a comprehensive literature review. The analysis is concentrated on manufacturing firms in Italy that have implemented Industry 4.0 technologies in their production processes. Through a structured questionnaire, data from 50 firms are collected. The relationships between various factors and the level of digital trust were examined. Employing a configurational approach, namely qualitative comparative analysis (QCA) (Ragin, 1989), which considers the combined impacts of multiple factors, this paper aims to study how different factors work together to enhance digital trust levels. Given that QCA is designed to elucidate how specific conditions jointly contribute to determining an outcome, the method is ideal for assessing the combined effects of factors in triggering digital trust.

The paper is organised as follows. Section 2 reviews the existing literature that forms the backdrop for this paper. Section 3 introduces the dataset and methodology. Section 4 outlines the implications, which are discussed then in Section 5. Finally, Section 6 concludes the paper by summarising insights and limitations.

Theoretical background

Several fields have addressed the issue of analysing the concept of trust considering the most disparate perspectives from medicine, and sociology to economics and many others (Al-Dwairi & Kamala, 2009). This shows that trust is a multifaceted concept applicable to numerous areas, and over the years, several academics have tried to give a comprehensive definition of this concept. Studies from the second half of the 20th century associated the term trust with the emotional and human sphere (Rotter, 1967; Gibb, 1978). Since the 2000s, trust has acquired the expression of an expectation and an individual will (Barbalet, 2009; Bos et al., 2002). To date, trust continues to evolve with the increasing array of technological innovations, broadening the sources people can depend on beyond traditional human relationships. However, the lingering question persists regarding the identification of truly reliable sources in this expansive landscape. The fragility of trust is not a new phenomenon, the speed and its visibility are new, indeed following the introduction of Industry 4.0 technologies, the concept of trust has acquired a novel meaning. Mubarak and Petraite (2020) developed a framework where digital trust is depicted as the intersection of trust and Industry 4.0 technologies. In this sense, digital trust can be defined as the stakeholders' confidence in the competence of actors, technologies, and processes to create reliable and secure business networks (Mubarak & Petraite, 2020). This concept is related to the relationship between individuals and the digital environment based on their perceptions and expectations. Furthermore, Marcial and Launer (2019), define digital trust as "the general belief that technology, people, and processes act or are aligned in ways that will meet people's digital expectations, such as a sense of trust, security, or control, to support the creation of a secure digital environment". Recognising and understanding the factors that influence digital trust is crucial in today's interconnected and technologically driven society. As organizations depend more on digital technologies, recognizing key elements is vital for secure digital environments. Stéphane Nappo of Société Générale emphasized this by noting, "It takes years to build reputation but just minutes of a cyber incident to destroy it". This eloquent quote emphasises the vulnerability of trust in the digital realm. To navigate the rapidly evolving threat landscape, organisations must adopt a clear and comprehensive strategy to avoid a reduction in trust among stakeholders. A comprehensive understanding of the elements impacting digital trust is essential to empower organisations developing a robust digital environment.

The formation of digital trust is therefore a complex interplay of different factors. Numerous theories and models have explored how to enhance trust in organizational contexts. Trust theory and organizational behavior stress the significance of trust in the organization, where consistent actions, communication, and fairness enhance a trustworthy environment (Lau & Höyng, 2023; Sunil Kumar & Sumitha, 2023). Customer Relationship Management model highlights how transparent communication, ethical behaviour, and consistent delivery of promises by organizations can lead to increased customer satisfaction, loyalty, and overall trust (Debnath, Datta & Mukhopadhyay, 2016; Demirel, 2022). Leadership trust principles further posit that trust in leadership is critical for fostering an environment of trust. Leaders who demonstrate integrity, competence, and benevolence significantly enhance trust among employees (Bencsik et al., 2022). Previous contributions also show how strategic planning, management support, and alignment with organizational goals during digital adoption foster trust (Lau & Höyng, 2023). Supporting evidence from the literature indicates that providing adequate training and support to employees enhances their trust in digital technologies by improving their competence and confidence, thus reducing resistance (Gkinko & Elbanna, 2023).

Given the multitude of perspectives, to explore the variables impacting digital trust, this study undertakes a comprehensive integrative literature review. This approach is optimal for conducting a critical analysis for the development of new conceptual frameworks (Durach, Kembro & Wieland, 2021; Mazumdar, Raj & Sinha, 2005; Snyder, 2019). Specifically, this article draws upon an integrative review of published studies on digital trust and related topics. In synthesizing the previous research, to understand the complexity of digital trust, this study draws upon the Technology Acceptance Model (TAM), which postulates that perceived usefulness and perceived ease of use significantly determine individuals' acceptance and use of technology (Davis, 1989). Two main streams of research emerge, focused on organization-related and process-related factors.

The first stream addresses organization-related factors, adopting a

behavioural perspective evaluating how external stimuli, changes, or challenges prompt employees to adapt their behaviors, skills, and strategies. The second stream concentrates on process-related factors, focusing on the aspects related to the efficiency and effectiveness of processes.

When combined with organizational theory and process-related principles, the TAM provides a robust framework for examining how various antecedents affect digital trust. Organizational theory provides insights into how organizational dynamics, such as culture and management strategies, shape trust within digital environments (Hobfoll, 2002; Luthans & Youssef, 2007). Meanwhile, previous research on successful process management shows how the systematic, efficient, and transparent execution of processes impacts stakeholders' trust in digital systems (Trkman, 2010; Qian & Papadonikolaki, 2021). Table 1 summarises the classification of organizational and process-related factors identified from the integrative literature.

Conceptual framework

The conceptual framework of this paper is designed to systematically analyze how organization-related factors and process-related factors work to build and maintain digital trust within an organization. Although prior research has examined trust from various angles—such as its emotional dimensions and its role in digital contexts—a gap remains in understanding digital trust in complex organizational ecosystems (Czakon et al., 2024; Van Der Schaft et al., 2024). Recent research by Marcial et al. (2024) investigates the relationship between employees' digital behaviors and trust levels in the workplace, focusing on their position within a socio-technological ladder and their interaction with ICT components. While this study highlights the importance of digital behavior in trust-building, it does not fully integrate digital trust with existing organizational theories or process frameworks, leaving a gap in understanding how digital trust is cultivated at the intersection of technology and organizational dynamics. Similarly, Gkinko and Elbanna (2023) explore the role of trust in interactions with AI-driven technologies, such as chatbots. Their research underscores the importance of trust in AI-human interactions but, like Marcial et al., does not address how broader organizational and process-related factors contribute to the development and sustenance of digital trust. As digital interactions expand beyond traditional human-to-human trust into human-technology interfaces, there is a pressing need to integrate organizational and process theories with digital trust to fully grasp its implications in modern technological settings. To bridge this gap, the present study aims to integrate the TAM with organizational and process principles to provide a more comprehensive understanding of digital trust. TAM, introduced by Davis (1989) posits that perceived usefulness and perceived ease of use are key determinants of individuals' acceptance of technology. However, while TAM provides valuable insights into technology adoption, it does not fully address the role of organizational structure, culture, and processes in shaping digital trust. By combining TAM with theories from organizational behavior—such as Luthans and Youssef (2007) on positive organizational behavior and Hobfoll's (2002) conservation of resources model—this study incorporates how organizational factors like leadership, culture, and training influence digital trust. In addition to organizational factors, process-related principles are critical for understanding how trust is operationalized in digital contexts. Guo and Yao (2022) and Qian and Papadonikolaki (2021) emphasize the importance of process standardization, risk management, and feedback mechanisms in ensuring the reliability and security of digital systems. These processes not only enhance technology acceptance but also ensure that digital trust is maintained through consistent and transparent operations. Given these considerations, this study presents a novel framework (illustrated in Fig. 1) to better understand the multifaceted nature of digital trust. This approach provides a more holistic view of how various antecedents interact to influence trust in digital environments. The proposed

Table 1
Classification of factors affecting digital trust (Author's own elaboration).

	Macro-Factors	Factors Affecting Digital Trust	References
ORGANIZATION-RELATED FACTORS	Top Management Defined Strategies (TMDS)	Perceived Effectiveness, Reputation, Image, Digital Vision, Leader-Member Exchange, Organizational Politics	(Au-Yong-Oliveira et al., 2022; Höyng & Lau, 2023; Lau & Höyng, 2023)
	Spread of Digital Culture (SDC)	Perceived Value, Attitude towards Technology, Technology Readiness, Behavioural Intention, Ethical Attributes, Competence, Inequity, Managerial Behavior, Transparency, Technological Impact, Behavioral Trait, Customer Satisfaction, Loyalty, Positive Experiences, Information Quality, Distinguishing Trustworthiness, Encouraging Trustworthy Behavior, Discouraging Untrustworthy Participation, Recommendation Accuracy, Trust Literacy Levels, Gratitude, Emotional Trust, Normative Trust, Organizational Norms, Creative Destruction, Service Quality, Brand Identity, Trust Sensitivity, Corporate Social Responsibility, Corporate Reputation, Price Sensitivity, Repeat Purchases	(Akhmedova, Vila-Brunet & Mas-Machuca, 2020; Ashrafi & Easmin, 2023; Barrane et al., 2021; Bilal et al., 2024; Chohan et al., 2022; Cserdi et al., 2022; Dąbrowska, Ozimek & Hrabynska, 2024; Demirel, 2022; Hallikainen, Hirvonen & Laukkanen, 2020; Mustafa et al., 2022; Sama, Stefanidis & Casselman, 2022; Vatankhah Barenji, 2022; Wziątek-Staśko & Pobiedzińska, 2024; Yamamoto et al., 2022; Yunus et al., 2022)
	Employees Adaptation (EA)	Customer Confidence, Government Support, Management Support, Social Technologic Ladder, ICT Component Trust, Employee Digital Behaviors, Emotional Trust, Cognitive Trust, Organizational Trust, Design Features for Trust	(Gkinko & Elbanna, 2023; Jain, Ajmera & Davim, 2022; Marcial et al., 2024)
	Employees Training (ET)	Data Trust, Analytical Models,	(Bencsik, Hargitai & Kulachinskaya,

(*continued on next page*)

Table 1 (*continued*)

	Macro-Factors	Factors Affecting Digital Trust	References
		Interpretive Capabilities, Digital Skills, Management Support, Perceived Usefulness, Perceived Ease of Use, Perceived Security, Risk-Free Experience	2022; Kurniasari, Gunawan & Utomo, 2022))
PROCESS-RELATED FACTORS	Process Automation (PA)	Device Authentication, Data Trust, Augmented Intelligence, Speculative Behavior, Asset Specificity, Interpersonal Trust, Transaction Costs, Property Rights, System-Based Trust, Cognition-Based Trust, Information Sharing, Smart Contracts, Contract Enforcement, Price, Past Transactions, Broad-Scope Trust, Third-Party Certifications, Legal Structures, Goodwill Trust, Communication Effectiveness, Relational Value, Digital Transformation, Informal Governance, Trust Issues, Process Quality, Risk, Trust Mining, Trust Policies, Process Resilience, Cognitive Trust, Affective Trust, Tacit Knowledge Sharing, Technological and Organizational Factors	(Capestro et al., 2024; Faruquee, Paulraj & Irawan, 2021; Guo & Yao, 2022; Komdeur & Ingenbleek, 2021; Muller et al., 2021; Qian and Papadonikolaki 2021b; Singh & Park, 2023)
	Accident Reduction (AR)	Risk Management, Safety Protocols, Compliance Standards, Hazard Identification, Incident Analysis	(Faruquee et al., 2021; Jain et al., 2022; Kumar, Liu & Shan, 2020; Shin, 2019).
	Information Traceability (IT)	Data Security Concerns, Direct-Trust, Public-Review, Auditor-Trust, Trust Calculation Functions, Trust in Blockchain, Perceived Security, Privacy Protection, Attitudes Toward Blockchain, User Traits, Data Access, Data Ownership, Data Sharing, Privacy, Property Rights, Security Features, Utility Features, Integrity, Perceived Risk, Trust, Privacy, Trust and Visibility, Information Accuracy, Speed of Information, Information Abundance, Transparency, Privacy Protection	(Alqahtani & Albahar, 2022; Chahal & Singh, 2017; Ertz & Boily, 2019; Kumar & Chopra, 2022; Kumar, Liu & Shan, 2020; Mazzei et al., 2020; Rogerson & Parry, 2020; Tan & Saraniemi, 2023; Treiblmaier & Gorbunov 2022; Trivedi et al., 2022)
	Cost and Duration of Digital Transformation (CDM)	Cost Efficiency, Duration of Implementation, Budget Adherence, Time-to-Value, Cost Reduction,	(Faruquee et al., 2021; Gkinko & Elbanna, 2023; Kumar et al., 2020)

framework moves beyond individual technology acceptance to explore how the intersection of technology, organizational structure, and process principles shapes stakeholders' confidence in an organization's digital interactions, offering a more robust and comprehensive perspective on digital trust in the modern age. The conceptualization of this framework revolves around two key propositions that articulate how each set of factors influences the overall level of digital trust. Together, they create a comprehensive approach to understanding and fostering digital trust in an organization. Below, it is explained how each proposition is developed and each mentioned macro-factor, defined in Table 1, contributes to enhancing the level of digital trust.

Organization-related factors

At the heart of this framework are organizational-related factors that significantly shape digital trust (Capestro et al., 2024; Srivastava et al., 2022). These factors provide the structural and cultural support needed to foster a secure and trustworthy digital environment, aligning closely with TAM's emphasis on perceived ease of use and usefulness. Five key organizational factors have been identified as critical to the development of digital trust: Top Management Defined Strategies (TMDS), Spread of Digital Culture (SC), Employee Adaptation (EA), Employee Training (ET), and Technostress (TS). The role of top management in shaping digital trust cannot be overstated. TMDS are pivotal in setting the direction for digital transformation within the organization. When leadership actively defines and supports digital initiatives, they not only allocate resources but also embed digital efforts within the broader organizational goals, which increases perceived usefulness among employees (Luthans & Youssef, 2007). Research indicates that strategic involvement from leadership fosters a sense of reliability and purpose in digital transformation efforts, making these technologies feel more integrated into the organizational landscape. This alignment is crucial for building digital trust because it reassures employees that the organization is committed to securely and effectively managing digital tools (Lau & Höyng, 2023). Numerous scholars have emphasized that effective leadership in the digital context has a significant positive impact on a firm's overall innovation performance, creating fertile ground for the development and enhancement of digital trust (Benitez et al., 2022; Fatima & Masood, 2024; Mo et al., 2023). By fostering an environment conducive to digital transformation, digital leaders create the conditions necessary for trust to flourish, as they guide the organization in adopting

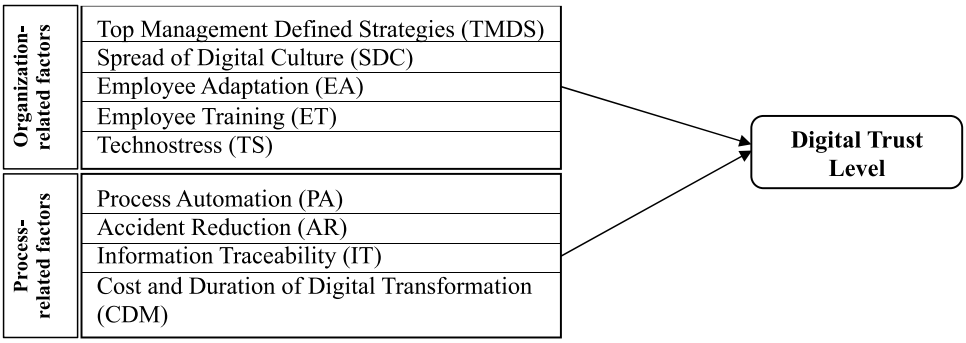

Fig. 1. Conceptual framework (Author's own elaboration).

secure, efficient, and innovative digital practices. This alignment of leadership with technological advancement reinforces employees' confidence in the organization's digital capabilities, further supporting the proposition that organizational-related factors are key antecedents of digital trust. Another critical factor is the SDC, which promotes an environment where digital initiatives are embraced and normalized. A robust digital culture fosters openness, innovation, and collaboration, all of which are key to ensuring that employees trust and utilize digital tools effectively. Studies have shown that organizations with a strong digital culture see higher acceptance of new technologies, as employees perceive them as both useful and easy to use (Wziątek-Staśko & Pobiedzińska, 2024; Yunus et al., 2022). Research indicates that culture significantly influences technology adoption and development processes (Butt et al., 2024; Gurbaxani & Dunkle, 2019; Leidner & Kayworth, 2006). Leaders must navigate both internal and external cultural landscapes to facilitate digital transformation (Volberda et al., 2021). Neglecting these cultural dynamics can hinder trust-building within organizations and with partners (Kolagar, Parida & Sjödin, 2022). Successful cultural refreshment during transformations can drive necessary shifts in mindset and capabilities (Ghosh et al., 2022; Warner & Wäger, 2019). This cultural support also aligns with TAM, as it enhances both the perceived ease of use and usefulness of digital technologies, crucial factors for building trust.

EA to digital technologies is another crucial component of fostering digital trust. Employees' ability to effectively integrate digital tools into their workflows is often influenced by the level of support provided by the organization. When organizations invest in fostering adaptability through a supportive learning environment, employees are more likely to perceive digital tools as easy to use and beneficial, enhancing both their trust in the technology and their willingness to adopt it (Marcial et al., 2024). A structured adaptation process is key to fostering digital trust, especially among new employees. When expectations are clearly communicated and the onboarding process is consistent across departments, it not only provides clarity but also demonstrates the organization's reliability and transparency (Suvalova et al., 2021). This sense of predictability helps employees feel more secure in navigating digital systems and trusting the organization's digital environment. This again aligns with TAM's assertion that perceptions of ease of use and usefulness drive technology acceptance. In tandem with adaptation, ET is essential for building digital trust. Comprehensive and ongoing training programs equip employees with the skills and confidence needed to use digital tools effectively (Gkinko & Elbanna, 2023). Effective training increases employees' perceived ease of use and perceived usefulness of these tools, both of which are central to TAM's framework. According to Goulart et al. (2021), one of the main barriers to effective digital transformation for managers was the lack of comprehensive employee training in both personal and technical skills. This training is essential for building digital trust, as employees who are well-prepared through targeted training programs are more likely to feel confident in using new digital tools and systems. As a result, organizations that prioritize training are better able to cultivate digital trust by ensuring that employees feel competent and confident in using the technology. Lastly, the issue of TS must be addressed to sustain digital trust. TS refers to the anxiety or stress employees experience when adapting to new digital tools and processes. Studies have shown that organizations that manage technostress effectively—through support systems and a positive work environment—are better able to foster digital trust (Ayyagari et al., 2011; Marcial et al., 2024). By reducing the negative impacts of technology on employee well-being, organizations can enhance trust by making digital tools feel more manageable and less overwhelming. Together, these organizational-related factors—TMDS, SDC, EA, ET, and TS—form the bedrock of digital trust. If effectively managed, these factors could create an environment where employees feel supported, equipped, and confident in their interactions with digital tools, which aligns closely with TAM's focus on perceived ease of use and usefulness. In light of this, the following proposition is formulated:

Proposition 1. *Organizational-related factors are antecedents of digital trust.*

Process-related factors

Process-related factors play a pivotal role in shaping and influencing digital trust within organisations. While organizational factors provide the groundwork for digital trust, process-related elements ensure its operationalization. Process-related factors that influence digital trust include Process Automation (PA), Accident Reduction (AR), Information Traceability (IT), and Cost and Duration of Digital Transformation (CDM). PA enhances the reliability and efficiency of workflows. Automation minimizes human error, reduces redundancy, and streamlines operations, making digital processes more predictable and dependable. This consistency instils confidence among employees, who come to rely on automated systems as trustworthy components of their work environment. Research shows that automation significantly enhances perceived ease of use and perceived usefulness, thereby fostering digital trust (Guo & Yao, 2022; Qian & Papadonikolaki, 2021). Another critical process-related factor is linked to safety, particularly the role of digital systems in Accident Reduction (AR). Technologies that improve workplace safety not only protect employees but also build trust, as they are seen as reliable and essential for maintaining a secure environment. Employees are more likely to trust systems that contribute to their well-being, reinforcing the perception of these technologies as both useful and easy to interact with. Studies have shown that when digital systems contribute to a safer working environment, trust in these systems increases (Shin, 2019). This aligns with TAM, as safety-enhancing technologies are perceived as useful and easy to use. Information traceability (IT) is also central to establishing trust. Transparent and auditable digital processes allow for accountability, ensuring that actions within the system can be tracked and verified. This transparency builds trust by demonstrating that the technology is not only functional but also fair and dependable. Research indicates that transparency and traceability in information processes significantly improve perceived

ease of use and perceived usefulness, leading to higher levels of digital trust (Tan & Saraniemi, 2023; Treiblmaier & Gorbunov, 2022) employees can trace and audit digital activities, their confidence in the system's reliability and integrity increases, aligning with TAM's emphasis on perceived usefulness and ease of use. Finally, CDM significantly impacts digital trust because projects that are completed efficiently, on time, and within budget are viewed as more reliable, fostering trust in both the process and the digital tools involved. When digital transformations are well-managed, employees are more likely to perceive the resulting systems as valuable and straightforward, further reinforcing trust in the organization's technological direction. Studies suggest that well-managed digital transformations enhance perceived ease of use and perceived usefulness, thereby fostering digital trust (Gkinko & Elbanna, 2023). Drawing on these premises, the second proposition is developed:

Proposition 2. *Process-related factors are antecedents of digital trust.*

In line with previous contributions (Huang et al., 2022; Yao and Li 2023), analyzing these propositions using fsQCA will provide a nuanced understanding of how various combinations of factors contribute to digital trust. This methodological approach allows to uncover the complex causal relationships that drive trust in digital environments, thereby offering valuable insights for both researchers and practitioners (Kraus, Ribeiro-Soriano & Schüssler, 2017; Roig-Tierno, Huarng & Ribeiro-Soriano, 2016). Furthermore, fsQCA's capacity for empirical identification of success paths and its adaptability for follow-up analysis make it a valuable tool for gaining comprehensive insights into digital trust dynamics. By integrating the Technology Acceptance Model with organizational and process theories, a more holistic understanding of the antecedents of digital trust can be developed, ultimately contributing to more effective digital transformation strategies.

Methodology

Data

The sampling strategy for this study was designed with several key considerations to ensure the relevance and depth of the analysis. Italian manufacturing companies were selected to focus on a sector that is critically important to the country's economy as well as significantly impacted by technological advancements (Gary & Shih, 2009). The manufacturing sector was chosen to comprehensively focus on the impacts of technologies on both the production process and the organisational and managerial aspects. The companies were selected by choosing those belonging to the ATECO section: Manufacturing Activities and who have collaborated with the University of Naples Federico II in prior digitalization projects. By selecting companies from the ATECO section of Manufacturing Activities, the study ensures that the sample is well-defined and representative of the manufacturing industry. The ATECO code, which is analogous to international classification systems like ISIC, provides a standardized way to categorize businesses, ensuring consistency and comparability in the data collected (Istat, 2007; United Nations, 2008). Furthermore, the pre-existing relationship of companies in Universities' projects increased the willingness of companies to participate and provided a sample already familiar with technological advancements, which is relevant to the study's focus on technology impacts (Perkmann & Walsh, 2007; Rosenberg, 1990). The companies were selected to cover a wide range of sizes (micro, small, medium, and large enterprises), geographic areas (North, Center, South and Islands), and industry sectors (e.g., Food, Pharmaceutical/Cosmetics, Mechanical, Electrical/Electronic). This diversity ensures that the findings can be generalized across different contexts within the manufacturing sector (Patton, 2014; Yin, 2014). Companies involved in prior digitalization projects were specifically targeted to align with the study's emphasis on technology's impact. This ensures that the participants have relevant experience and insights into the technological changes and their effects on manufacturing processes and organizational structures (Brynjolfsson & McAfee, 2014; Geissbauer, Vedso & Schrauf, 2016). Out of over 300 companies contacted, 62 agreed to participate, and 50 were deemed suitable for analysis. This selection process ensured that the final sample was not only willing but also met the criteria necessary for the study, thus enhancing the reliability and validity of the results (Baruch & Holtom, 2008; Groves & Peytcheva, 2008). Table A1 in the appendix presents details of the participants who took part in the study.

Analytical approach

Once the study's variables had been identified through the literature review, the questionnaire was designed. The survey was in Italian and comprised of four sections. The first section investigates companies' adoption of Industry 4.0 technologies by exploring the types implemented from the 9 macro-categories defined by Boston Consulting Group (Rüßmann et al., 2015) and time since introduction. In this first section, the sample of respondents was narrowed down to only those from companies that have adopted Industry 4.0 technologies for at least one year. The second section regards respondents and the company's socio-demographic information. In the third section, respondents were invited to answer by expressing their level of agreement or disagreement on a five-item Likert scale ranging from 1 = "Strongly disagree" to 5 = "Strongly agree" about organizational-related factors and process-related factors. For instance, concerning the TMDS variable, the inquiry was framed as follows: "Following the introduction of Industry 4.0 technologies, the top management has established appropriate strategies to promote digital transformation". Finally, in the fourth section, respondents were asked to rate their level of feelings of trust after the implementation and use of technologies on a five-item Likert scale ranging from 1 = "Strongly disagree" to 5 = "Strongly agree". In particular, the question was: "After the implementation and utilization of Industry 4.0 technologies, there has been an increase in employees' trust in them". More in detail, the questionnaire was designed not to give the interviewee the impression of specifically analysing trust levels to ensure unbiased responses.

Fuzzy set qualitative comparative analysis

The methodology employed is qualitative comparative analysis (QCA). QCA is a data analysis technique that combines the logic of a qualitative approach with quantitative methods (Ragin, 2008). In particular, in this research, fuzzy set qualitative analysis (FsQCA) has been chosen to identify necessary and unnecessary conditions for the manifestation of the outcome and to determine which combinations of conditions are more important than others. The choice fell on this approach because it overcomes the weaknesses of traditional statistical methodologies (e.g., structural equation modelling, simple regressions, etc.) and allows researchers to predict complex and uncertain phenomena (Daniel & Daniel, 2019; Tapsell & Woods, 2010). Indeed, according to Kumar et al. (2022), there has been an increase in the number of studies adopting FsQCA and complex theory in business and management research, witnessing the strengths and potential of this methodology in the field. Furthermore, this approach is particularly useful with a limited sample size (up to 50 cases) (Greco et al., 2022; Hernández-Perlines, Moreno-Garcia & Yáñez-Araque, 2016). The methodology comprises several steps. The process begins with data calibration, converting raw data into fuzzy set scores between 0 and 1, where 1 indicates full membership and 0 indicates non-membership (Ragin, 2008). This study used indirect calibration, selecting thresholds based on data distribution, with values of 4, 3, and 2 for calibration as presented in Table 2. For instance, "Strongly agree" is calibrated to 1, "Strongly disagree" to 0, and "Neutral" to 0.5. Next, a truth table is constructed to identify causal combinations sufficient to produce the outcome. The table includes all possible combinations of causal conditions and shows the number of cases for each combination, as well as the

Table 2
Fuzzy-set membership calibrations (Author's own elaboration).

Variable Name	Type	Fully in	Crossover	Fully out	Mean	Dev St.
Digital Trust level (DT)	Outcome	4	3	2	3.74	0.69
Top Management Defined Strategies (TMDS)	Antecedent	4	3	2	4.08	0.77
Spread of Digital Culture (SDC)	Antecedent	4	3	2	4.02	0.91
Employee Adaptation (EA)	Antecedent	4	3	2	2.98	0.86
Employees Training (ET)	Antecedent	4	3	2	3.96	0.60
Process Automation (PA)	Antecedent	4	3	2	3.82	1.01
Accident Reduction (AR)	Antecedent	4	3	2	3.88	1.03
Information Traceability (IT)	Antecedent	4	3	2	4.32	0.68
Cost and Duration of Digital Transformation (CDM)	Antecedent	4	3	2	3.88	0.82

consistency of each configuration in producing the outcome. Necessary conditions are analyzed to determine if their presence is essential for the outcome (Ragin, 2008). FsQCA then uses Boolean minimization to identify combinations of conditions sufficient for the outcome, evaluated based on consistency (how often the outcome occurs with a specific condition) and coverage (how much of the outcome is explained by each configuration) (Ragin, 2008; Schneider & Wagemann, 2012; Thiem, Baumgartner & Bol, 2015). Consistency above 0.7 indicates a necessary condition, while sufficient conditions require consistency above 0.7 and coverage of at least 0.5. FsQCA produces three solutions: complex, parsimonious, and intermediate. The complex solution avoids simplifying assumptions, the parsimonious solution minimizes conditions, and the intermediate solution balances complexity by integrating some simplifying hypotheses (Schneider et al., 2010; Schneider & Wagemann, 2012). The two models analysed are as follows:

Model 1: Digital Trust = f (TMDS, SDC, EA, ET, TS);
Model 2: Digital Trust = f (PA, AR, IT, CDM).

Analysis of the results

Descriptive analysis

Table 3 provides the socio-demographic characteristics of both the survey respondents and their companies. Most respondents were male (82 %), with a smaller proportion being female (18 %). Respondents were fairly evenly distributed across age groups, with 26 % under 35, 26 % between 36 and 45, and 48 % over 35. A significant portion of respondents held a master's degree (62 %) or above (Doctorate - 22 %). Furthermore, the majority of respondents held managerial roles (74 %), while some were in production areas (12 %), and commercial/administrative areas (10 %).

Concerning the socio-demographic factors of the companies, the presence of women in the workforce is very low, with 38 % reporting <20 % women and also <20 % of the employees holding a bachelor's degree. The average age of employees skewed towards the 36–45 age group (64 %). The mechanical sector was the most represented (30 %), followed by the food sector (22 %), electrical/electronic (10 %), and others with smaller percentages. Companies were spread across the North (46 %), Centre (28 %), and South/Islands (26 %). Most companies fell into the small (32 %) and medium (40 %) size categories.

Concerning the adoption of Industry 4.0 technologies, cloud technology is widely adopted, with half of the companies in the study leveraging cloud services. This indicates a significant reliance on cloud infrastructure for data storage, processing, and other business operations. Big Data Analytics (BDA) is also prevalent, being adopted by a substantial portion of companies (36 %). This suggests a recognition of the importance of analysing large datasets to gain valuable insights and inform decision-making processes. Blockchain technology adoption is moderate, with 16 % of companies incorporating it into their operations. This may indicate a specific interest in decentralised and secure transactional systems. Artificial intelligence (AI) adoption is on par with blockchain, indicating that a notable but not dominant proportion of

Table 3
Socio-demographic statistics (Author's own elaboration).

Socio-demographic Factors of the respondents		
	Frequency	**Percentage**
Gender		
Female	9	18 %
Male	40	80 %
Prefer not to disclose	1	2 %
Age group		
under 35	13	26 %
36–45	13	26 %
over 35	24	48 %
Education		
High school	8	16 %
Master's degree	31	62 %
Doctorate	11	22 %
Role		
Managerial roles (top executives, CEOs)	37	74 %
Employees in production areas	6	12 %
Employees in the commercial and administrative areas	5	10 %
Others	2	4 %
Socio-demographic factors of the companies		
Women in the Workplace		
<20 %	19	38 %
>80 %	3	6 %
20 %–40 %	17	34 %
40 %–60 %	8	16 %
60 %–80 %	3	6 %
Average age of employees		
18–25	1	2 %
26–35	12	24 %
36–45	32	64 %
over 45	5	10 %
Employees Bachelor's Degree Holders		
under 20 %	21	42 %
20 %–40 %	15	30 %
41 %–60 %	9	18 %
61 %–80 %	3	6 %
over 80 %	2	4 %
Industry sector		
Mechanical	15	30 %
Food Sector	11	22 %
Electrical/Electronic	5	10 %
Pharmaceutical/Cosmetics	5	10 %
Furniture	2	4 %
Industrial Automation - Mechatronics	2	4 %
Plastic	2	4 %
Other	8	
Geographic area		
North	23	46 %
Center	14	28 %
South and islands	13	26 %
Company size		
Micro (<10 employees)	4	8 %
Small (<50 employees)	16	32 %
Medium (<250 employees)	20	40 %
Large (over 250 employees)	10	20 %

companies are integrating AI technologies. AI can enhance various aspects of business operations, including automation and predictive analytics. Internet of Things (IoT) adoption is comparatively lower, with only 10 % of companies implementing IoT technologies. This might suggest that while IoT has its applications, it is not as universally embraced as other technologies. In addition, concerning the temporal dimension associated with the adoption and integration of Industry 4.0 technologies among the surveyed companies, a significant majority, comprising 76 % of respondents, falls within the 1–3-year span, indicating a recent and widespread embrace of these innovative technologies. Meanwhile, a notable 20 % of companies have been navigating the Industry 4.0 landscape for a duration spanning 4–10 years, showcasing a sustained commitment to technological advancement. A smaller yet noteworthy 4 % of respondents boast remarkable longevity in the integration process, with their journey extending over a decade. Table 4 summarises the results discussed.

Analysis of necessary and sufficient conditions

The analysis of necessary and sufficient conditions was performed through fsQCA software. In the models, calibrated variables are denoted with the suffix "_c", and the tilde (~) refers to the absence of the condition. As mentioned in Section 3.3, consistency must be higher than 0.70 for conditions to be necessary (Ragin, 2006, p. 293). In model 1, variables TMDS_c, SDC _c and ET_c are deemed necessary for the manifestation of the outcome. Specifically, the variable SDC_c exhibits the highest consistency level. The top management should communicate to employees the importance of adopting new technologies by fostering a digital culture within the organisation. In model 2, all the variables are necessary for the manifestation of the outcome. The variable IT_c has the highest consistency level, indicating a strong connection between this variable and the outcome. Presumably, the benefits in terms of control and reliability have been demonstrated and appreciated after the implementation of technologies, thus justifying the impact on digital trust levels. Conversely, consistency values for negated conditions are all <0.7 in both models. Results are summarised in Table 5.

Following the analysis of necessary conditions, sufficient conditions are evaluated (Tables 6 and 7). Regarding model 1, The intermediate and complex solutions (TDMS_c * SDC_c * ET_c) provide a high degree of explanation and reliability for digital trust, with high consistency (0.88) and coverage (0.88). The parsimonious solutions, while somewhat effective, do not match the robustness of the intermediate solution. Considering model 2, The IT_c condition in the parsimonious solution is highly effective with a raw coverage of 0.997 and a consistency of 0.85, uniquely covering almost all outcome cases. In the intermediate and complex solutions, both CDM_c * IT_c and AR_c * IT_c configurations demonstrate high coverage and consistency, with AR_c * IT_c showing the highest consistency. These two combinations of conditions lead to strong digital trust with high consistency, respectively equal to 0.87 for the first combination and 0.92 for the second combination. Both combinations share the presence of IT_c which is also a necessary condition.

Table 4
Industry 4.0 adoption and diffusion level (Author's own elaboration).

Level of adoption of Industry 4.0 technologies	Frequency	Percentage
Cloud	25	50 %
BDA	18	36 %
Blockchain	8	16 %
AI	8	16 %
IoT	5	10 %
Time from the introduction and implementation of Industry 4.0 technologies		
1–3 years	38	76 %
4–10 years	10	20 %
over 10 years	2	4 %

Table 5
Analysis of necessary conditions (Author's own elaboration).

Model 1		
Variables	**Consistency**	**Coverage**
TMDS_c	0.941401	0.861305
SDC_c	0.949045	0.871345
EA_c	0.568153	0.923395
ET_c	0.938854	0.841324
TS_c	0.495541	0.876126
~TMDS_c	0.157962	0.873239
~SDC_c	0.147771	0.800000
~EA_ c	0.555414	0.843327
~TS_c	0.624204	0.881295
~ET_c	0.157962	1.000000
Model 2		
Variables	**Consistency**	**Coverage**
CDM_c	0.880255	0.846814
PA_c	0.878981	0.892626
AR_c	0.892994	0.912760
IT_c	0.997452	0.845572
~CDM_c	0.222930	0.951087
~PA_c	0.219108	0.757709
~AR_c	0.248408	0.840517
~IT_c	0.071338	0.756757

Notes: Highlighted rows indicate that the condition's consistency reaches the 0.75 reference point.
(**Abbreviations**: Top Management Defined Strategies (TMDS); Spread of Digital Culture (SDC); Employee Adaptation (EA); Employee Training (ET); Technostress (TS); Process Automation (PA); Accident Reduction (AR); Information Traceability (IT); Cost and Duration of Digital Transformation (CDM)).

Discussion

The analysis of digital trust in Model 1 and Model 2 reveals its multifaceted nature and the interactions between various influencing factors. Model 1 identifies TMDS, SDC, and ET as the most significant organizational factors affecting digital trust. These factors are necessary for the outcome to occur, and their combination creates a sufficient condition for fostering trust. The model highlights that the combination of TMDS, SDC, and ET leads to the highest consistency and coverage for building digital trust (Consistency: 0.881). This demonstrates that digital trust is not just a matter of strategy or training in isolation but requires a synchronized effort across all three areas. The theoretical novelty lies in this triadic relationship where digital culture amplifies the effects of strategic direction and training, showing a path for future research on multi-factor digital adaptation models. This is consistent with Kane et al. (2015) who found that organizations prioritizing strategy over technology are more successful in digital transformation. Their research emphasizes that a clear digital strategy led by top management is critical for success, echoing our findings on TMDS's impact on digital trust. Organizational behavior research also supports the need for top management support and strategic alignment in building a trustworthy digital environment (Lau & Höyng, 2023; Luthans and Youssef, 2007).

The role of SDC aligns with Kane et al.'s view that a strong digital culture is essential for achieving digital maturity. Our findings confirm that a culture of openness and collaboration enhances trust in digital tools, paralleling the Customer Relationship Management (CRM) model that links transparency and innovation to trust and satisfaction (Yunus et al., 2022). Additionally, ET's significance mirrors Venkatesh et al. (2016) who stressed that user knowledge and competence are vital for fostering positive attitudes toward new technologies. Effective training boosts employees' confidence in using digital tools, increasing their trust in these technologies (Gkinko & Elbanna, 2023), underscoring the need for comprehensive training programs to address perceived ease of use and usefulness (Marcial et al., 2024).

In Model 2, process-related factors are examined, revealing different

Table 6
Sufficiency analysis for model 1 (Author's own elaboration).

Model 1: DT= *f* (TMDS, SDC, EA, ET, TS)						
Solution Type	**Configuration**	**Raw Coverage**	**Unique Coverage**	**Consistency**	**Solution Coverage**	**Solution Consistency**
Parsimonious	TDMS_c	0.446512	0	0.676056	0.567442	0.559633
	ET_c	0.353488	0.0697675	0.612903		
	SDC_c	0.488372	0.0465116	0.724138		
Intermediate	TDMS_c * SDC_c*ET_c	0.877707	0.877707	0.881074	0.877707	0.881074
Complex	TDMS_c * SDC_c*ET_c	0.877707	0.877707	0.881074	0.877707	0.881074

(Abbreviations: Digital Trust (DT) Top Management Defined Strategies (TMDS); Spread of Digital Culture (SDC); Employee Adaptation (EA); Employee Training (ET); Technostress (TS)).

Table 7
Sufficiency analysis for model 2 *(Author's own elaboration)*.

Model 2: DT= *f* (PA, AR, IT, CDM)						
Solution Type	**Configuration**	**Raw Coverage**	**Unique Coverage**	**Consistency**	**Solution Coverage**	**Solution Consistency**
Parsimonious	IT_c	0.997452	0.997452	0.845572	0.997452	0.845572
Intermediate	CDM_c*IT_c	0.878981	0.0929937	0.872314	0.984713	0.857936
	AR_c*IT_c	0.89172	0.105733	0.91623		
Complex	CDM_c*IT_c	0.878981	0.0929937	0.872314	0.984713	0.857936
	AR_c*IT_c	0.89172	0.105733	0.91623		

(Abbreviations: Digital Trust (DT) Process Automation (PA); Accident Reduction (AR); Information Traceability (IT); Cost and Duration of Digital Transformation (CDM)).

dimensions of their impact on digital trust. The parsimonious solution demonstrates the dominance of IT that alone covers almost the entire solution space (Raw Coverage: 0.997), showing that traceability is the most significant driver of digital trust. This finding supports Marcial's (2019) definition of digital trust, which emphasizes reliable data management. The strong consistency of IT underscores its central role in establishing and maintaining digital trust (Chahal & Singh, 2017; Treiblmaier & Gorbunov, 2022). Additionally, findings show novel combinations like CDM and IT or AR and IT with high consistency (0.872 and 0.916, respectively). This suggests that cost management and safety improvements are effective in building trust, but only when combined with information traceability, highlighting the need for integrated strategies in theory-building. For example, process automation and cost efficiency improve ease of use and usefulness, fostering trust (Gkinko & Elbanna, 2023; Qian & Papadonikolaki, 2021). This aligns with broader research showing that effective management of digital transformation processes contributes to higher trust levels (Faruquee et al., 2021). Technologies that reduce accidents and enhance safety contribute to perceptions of reliability (Shin, 2019), reinforcing the idea that safety-enhancing technologies are perceived as more trustworthy (Kumar et al., 2020). These results align with contemporary research advocating for a holistic approach to digital trust that considers both individual and combined effects of various factors (Huang et al., 2022; Yao & Li, 2023).

Fig. 2 summarizes the main findings and provides recommendations for managers in the manufacturing sector seeking to enhance digital trust by differentiating actions based on organizational and process factors. These results serve as a comprehensive recipe for building and enhancing digital trust within organizations. The combinations outline critical factors that contribute to creating a trustworthy digital environment, highlighting the importance of each component and how they interact to foster trust among stakeholders.

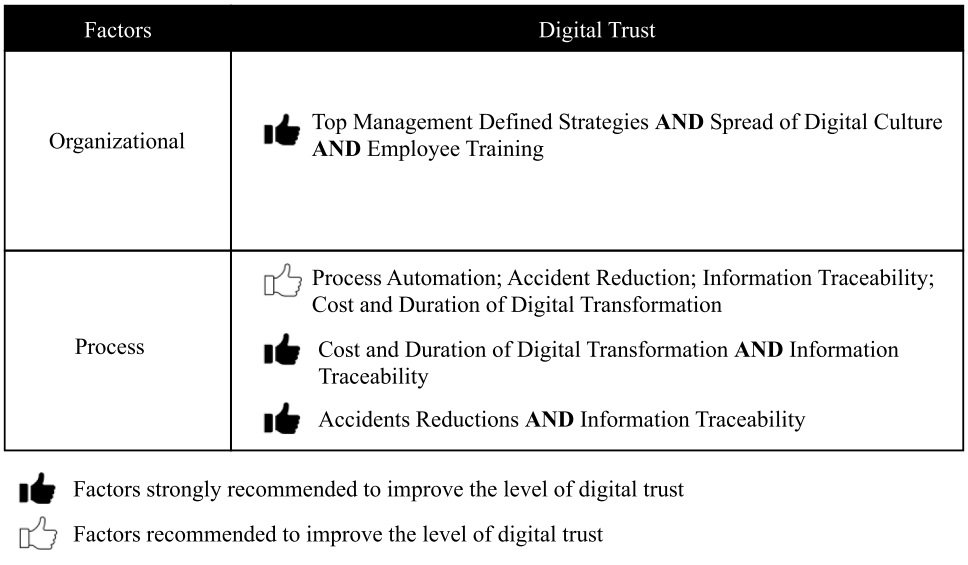

Fig. 2. Recommended factors to enhance digital trust (Author's own elaboration).

Theoretical implications

This study extends the theoretical framework of digital trust by showing it is not solely a result of technology acceptance (as posited by TAM) but is also shaped by organizational and process-related factors. Model 1 highlights the importance of TMDS, SDC, and ET in fostering digital trust, illustrating that TAM alone is insufficient to fully capture these dynamics. Organizational factors such as top management support, digital culture, and training influence perceptions of technology's ease of use and usefulness. This integrated approach connects technology acceptance with organizational behavior theories, filling a gap in the literature that often overlooks the interaction between these domains.

For example, TMDS's role in digital trust is consistent with Kane et al.'s (2015) findings that strategy, not technology, drives digital transformation in mature organizations. Similarly, the importance of SDC reflects the CRM model, which links transparency and innovation to trust and satisfaction (Yunus et al., 2022). ET's significance aligns with research on user competence development, which is essential for creating a supportive environment for digital transformation (Sharma et al., 2022). Comprehensive training programs that address ease of use and usefulness are essential to enhance employee confidence and trust in digital technologies (Marcial et al., 2024).

Process-related factors such as IT, AR, and CDM also play a critical role in building digital trust. The study extends TAM by showing that digital trust is not only about how useful or easy technology is perceived to be but also about how well the processes surrounding these technologies are managed. Transparent and traceable processes are crucial for fostering trust, and the findings demonstrate that process automation and safety-enhancing technologies increase both trust and perceptions of reliability (Shin, 2019; Kumar et al., 2020). Contemporary research supports this holistic view, emphasizing the need to consider both individual and combined effects of various factors to enhance digital trust (Huang et al., 2022; Yao & Li, 2023).

Managerial implications

This study offers a novel contribution to managers, particularly in the manufacturing sector, by outlining specific actions that can foster digital trust in organizational settings. In this industry, where technological advancements like automation, AI, and digital transformation are reshaping operations, digital trust becomes critical to both operational efficiency and workforce adaptation. Managers in manufacturing must recognize that trust is not solely reliant on the functionality of technology but on how well top management actively supports digital strategies and promotes a strong digital culture. For manufacturers, this means aligning digital initiatives with production goals, ensuring that technology adoption integrates seamlessly with existing processes and that employees trust the reliability of new tools, especially those tied to production safety and quality. Additionally, in manufacturing environments where rapid changes in technology can cause resistance among workers, effective training programs are crucial. Training must extend beyond the functional use of technology to address concerns about automation and potential job displacement. By focusing on continuous, comprehensive training, managers can reduce technostress, enhance employee adaptability, and foster trust in digital initiatives. This is particularly relevant in the context of advanced manufacturing, where workers need to feel confident in both their ability to operate new systems and the reliability of those systems to perform safely. On the process side, managers must ensure that digital transformation in manufacturing prioritizes not only cost efficiency and production speed but also transparency, safety, and traceability. For instance, transparent data on production processes and safety-enhancing technologies such as automated accident prevention systems are critical in building trust. In this sector, where safety and precision are paramount, information traceability and accident reduction mechanisms play an essential role in gaining the trust of the workforce and external stakeholders. Managers should invest in technologies that both enhance production and provide clear, traceable data on performance, which can mitigate concerns about system reliability.

Given these findings, future studies should consider expanding actual evidence in diverse industry contexts. Additionally, the dynamic nature of digital trust and rapid technological changes highlight the need for longitudinal research to track how trust evolves and to ensure that the findings remain relevant. Ongoing adaptation of strategies will be crucial as technology and organizational dynamics continue to evolve. Table 8 summarises the main avenues for future research.

Conclusion

This study offers a critical advancement in understanding digital trust within organizations, addressing a notable gap in the current body of research. Despite the extensive debate on digital trust and the impact of Industry 4.0 technologies, existing literature has partially explored the specific factors influencing digital trust levels. By conducting an integrative literature review, factors that impact digital trust have been identified and categorized.

This research contributes to the field by developing a taxonomy that distinguishes between process and organizational factors and defining two theoretical models using fsQCA to capture the complex nature of digital trust. The framework was applied to a sample of 50 Italian

Table 8
Future research directions.

Future Research Question	Description	Potential Impact
1. How can the identified factors and models of digital trust be applied to industries beyond manufacturing?	Investigate the applicability of the identified factors and models in industries other than manufacturing.	Provides broader insights into digital trust across various sectors, enhancing the generalizability of findings.
2. How does digital trust evolve over time with technological advancements and organizational changes?	Conduct studies that track digital trust over time to understand its development, evolution, and sentiment before and after technological changes.	Offers a dynamic perspective on how trust develops and shifts with technological and organizational transformations.
3. What is the impact of cutting-edge technologies (e.g., artificial intelligence, blockchain) on digital trust?	Explore the impact of specific emerging technologies on digital trust.	Expands the theoretical framework to include modern technological advancements and their effects on digital trust.
4. How do different aspects of organizational culture (e.g., leadership styles, communication practices) influence digital trust?	Investigate how various elements of organizational culture impact digital trust.	Identifies cultural elements that significantly affect digital trust, leading to targeted interventions for improvement.
5. How can trust models be developed and tested to focus on end-users' perspectives and experiences with digital technologies?	Develop and test trust models that prioritize end-user's perspectives and experiences with technology.	Ensures that trust models are relevant to actual users, enhancing their practical applicability.
6. How effective are various digital transformation strategies in building and maintaining digital trust?	Analyze the effectiveness of different strategies for digital transformation on digital trust.	Provides actionable insights for designing and implementing effective digital transformation strategies.
7. How does digital trust influence employee engagement, including job satisfaction and productivity?	Explore the relationship between digital trust and employee engagement factors such as job satisfaction and productivity.	Offers insights into how trust impacts overall employee performance and organizational outcomes.

manufacturing companies. Specifically, the proposed framework draws an explicit connection between organizational-related and process-related factors as antecedents of digital trust, aligning with two research propositions. Proposition 1 explores the relationship between organizational-related factors and digital trust and is reflected in the identification of key variables impacting the level of trust. The most relevant factors identified include top management's commitment to clear strategic direction, the development of a digital culture, and employee training. These intangible elements—knowledge dissemination, culture, and shared objectives—are shown to be crucial in increasing trust in technology. This insight challenges traditional frameworks that prioritize tangible elements such as tools and infrastructure, offering a more holistic understanding of trust development.

Proposition 2 asserts that process-related factors serve as antecedents of digital trust. The analysis reveals that the configuration of various solution types significantly influences the level of digital trust. Specifically, the first configuration involves information traceability alone, while the other configurations combine accident reduction and information traceability with investments in digital transformation. These findings suggest that a balanced strategy that incorporates both human elements, such as accident reduction and transparency, and technological advancements, like effective digital transformation, is crucial for building and maintaining digital trust in the organization.

This study significantly advances the theoretical landscape of digital trust by providing a structured approach to understanding how these various elements—both organizational and process-oriented—interact. It integrates intangible factors like digital culture and knowledge sharing, highlighting their role in shaping trust in complex digital environments. This nuanced perspective opens new avenues for future research to explore these dimensions more deeply.

In practical terms, this study offers a trust-building recipe that provides organizational leaders with actionable strategies to foster digital trust within their teams, considering both process-related and organizational-related factors. One of the key ingredients is the importance of top management's commitment to defining clear digital strategies and fostering a supportive digital culture. Investments in both time and financial resources for digital transformation are essential, as is the development of robust information traceability systems to enhance transparency and accountability. Furthermore, organizations are encouraged to minimize disruptions and maintain stakeholder confidence by implementing advanced process management techniques, improving operational efficiency by ensuring safety. While this study provides valuable insights, it is important to acknowledge limitations. One of the primary limitations is the focus on the manufacturing sector, which may limit the generalizability of the findings to other industries. In addition, while this study focuses on organizational and process-related factors, other potential influences on digital trust—such as individual characteristics, regional differences, or cultural attitudes towards technology—are not fully explored. Factors like technology readiness, regulatory environments, and cultural norms may significantly impact digital trust, especially in global organizations or across different geographic regions

Professionally Proofread

Fostering Digital Trust in Manufacturing Companies: Exploring the Impact of Industry 4.0 Technologies

Lynette Sharp

28th October 2024

This is to certify that this study has been professionally proofread in line with the Journal of Innovation and Knowledge.

CRediT authorship contribution statement

Serena Strazzullo: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

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Appendix

Table A.1

Table A.1
Details of informants.

Companies	Gender	Instruction level	Industry Sector	Geographic area	Company Size	Role
1	Male	Master's degree	Food	North	Small company (<50 employees)	Managerial roles (top executives, CEOs).
2	Male	Master's degree	Pharmaceutical/Cosmetics	Center	Small company (<50 employees)	Managerial roles (top executives, CEOs).
3	Male	Doctorate	Food	South and Islands	Large company (<250 employees)	Employee in the commercial area (Customer service, marketing, sales).
4	Female	Master's degree	Food	Center	Medium company (<250 employees)	Employee in the commercial area (Customer service, marketing, sales).
5	Male	High school	Rubber and Plastic	Center	Large company (>250 employees)	Employees (operator, production manager, quality inspector, maintenance technician, production technician, engineer)
6	Male	Master's degree	Mechanical, Electronic, Computer, All Engineering	North	Large company (>250 employees)	Human resources manager
7	Male	Master's degree	Pharmaceutical/Cosmetics	South and Islands	Micro company (<10 employees)	Managerial roles (top executives, CEOs).
8	Male	Master's degree	Mechanical	North	Medium company (<250 employees)	Employees (operator, production manager, quality inspector, maintenance technician, production technician, engineer)
9	Male	Master's degree	Electrical/Electronic	North	Large company (>250 employees)	Managerial roles (top executives, CEOs).

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Table A.1 (*continued*)

Companies	Gender	Instruction level	Industry Sector	Geographic area	Company Size	Role
10	Male	Master's degree	Mechanical	North	Large company (>250 employees)	Managerial roles (top executives, CEOs).
11	Male	Doctorate	Mechanical	North	Medium company (<250 employees)	Managerial roles (top executives, CEOs).
12	Male	High school	Mechanical	North	Medium company (<250 employees)	Employee in the commercial area (Customer service, marketing, sales).
13	Male	Doctorate	Manufacturing	North	Large company (>250 employees)	Managerial roles (top executives, CEOs).
14	Male	Master's degree	Printing	North	Small company (<50 employees)	Managerial roles (top executives, CEOs).
15	Male	Master's degree	Food	South and Islands	Small company (<50 employees)	Managerial roles (top executives, CEOs).
16	Male	Doctorate	Industrial - Production of infra-glass curtains	South and Islands	Small company (<50 employees)	Managerial roles (top executives, CEOs).
17	Female	Master's degree	Mechanical	North	Medium company (<250 employees)	Managerial roles (top executives, CEOs).
18	Male	Master's degree	Mechanical	South and Islands	Medium company (<250 employees)	Managerial roles (top executives, CEOs).
19	Male	Master's degree	Pharmaceutical/Cosmetics	Center	Small company (<50 employees)	Managerial roles (top executives, CEOs).
20	Male	Master's degree	Mechanical	North	Medium company (<250 employees)	Managerial roles (top executives, CEOs).
21	Female	Master's degree	Mechanical	North	Large company (>250 employees)	Employees (operator, production manager, quality inspector, maintenance technician, production technician, engineer)
22	Male	Master's degree	Industrial Automation - Mechatronics	North	Medium company (<250 employees)	Managerial roles (top executives, CEOs).
23	Male	Master's degree	Pet Food	South and Islands	Small company (<50 employees)	Employee in the commercial area (Customer service, marketing, sales).
24	Male	Master's degree	Plastic Manufacturing	North	Medium company (<250 employees)	Managerial roles (top executives, CEOs).
25	Prefer not to disclose	High school	Mechanical	North	Medium company (<250 employees)	Managerial roles (top executives, CEOs).
26	Female	Master's degree	Mechanical	South and Islands	Small company (<50 employees)	Managerial roles (top executives, CEOs).
27	Female	High school	Food	South and Islands	Medium company (<250 employees)	Managerial roles (top executives, CEOs)
28	Female	Doctorate	Food	South and Islands	Small company (<50 employees)	Managerial roles (top executives, CEOs).
29	Male	High school	Food	North	Large company (>250 employees)	Risk Manager & GDPR Data Protection Coordinator
30	Male	Master's degree	Food	South and Islands	Medium company (<250 employees)	Managerial roles (top executives, CEOs)
31	Female	Master's degree	Mechanical	North	Large company (>250 employees)	Managerial roles (top executives, CEOs).
32	Male	High school	Artisan Manufacturing	Center	Small company (<50 employees)	Managerial roles (top executives, CEOs)
33	Male	High school	Mechanical	North	Medium company (<250 employees)	Managerial roles (top executives, CEOs).
34	Male	Doctorate	Electrical/Electronic	North	Large company (>250 employees)	Managerial roles (top executives, CEOs).
35	Male	Master's degree	DEFENSE Market	Center	Medium company (<250 employees)	Managerial roles (top executives, CEOs).
36	Male	High school	Electrical/Electronic	North	Medium company (<250 employees)	Employees (operator, production manager, quality inspector, maintenance technician, production technician, engineer)
37	Male	Master's degree	Electrical/Electronic	Center	Micro company (<10 employees)	Managerial roles (top executives, CEOs).
38	Male	Doctorate	Industrial Automation	Center	Small company (<50 employees)	Managerial roles (top executives, CEOs).
39	Male	Master's degree	Medical	North	Micro company (<10 employees)	Managerial roles (top executives, CEOs).
40	Female	Doctorate	Food	North	Medium company (<250 employees)	Employee in the commercial area (Customer service, marketing, sales).
41	Male	Master's degree	Electrical/Electronic	North	Micro company (<10 employees)	Managerial roles (top executives, CEOs).
42	Male	Master's degree	Pharmaceutical/Cosmetics	Center	Large company (>250 employees)	Managerial roles (top executives, CEOs).
43	Male	Doctorate	Luxury Furniture	Center	Small company (<50 employees)	Managerial roles (top executives, CEOs).
44	Male	Master's degree	Mechanical	South and Islands	Small company (<50 employees)	Employees (operator, production manager, quality inspector, maintenance technician, production technician, engineer)

(*continued on next page*)

Table A.1 (*continued*)

Companies	Gender	Instruction level	Industry Sector	Geographic area	Company Size	Role
45	Female	Doctorate	Mechanical	Center	Small company (<50 employees)	Employees (operator, production manager, quality inspector, maintenance technician, production technician, engineer)
46	Male	Master's degree	Food	South and Islands	Medium companies (<250 employees)	Managerial roles (top executives, CEOs)
47	Male	Master's degree	Food	South and Islands	Medium companies (<250 employees)	Managerial roles (top executives, CEOs)
48	Male	Master's degree	Pharmaceutical/Cosmetics	Center	Small companies (<50 employees)	Managerial roles (top executives, CEOs)
49	Male	Master's degree	Ceramic	Center	Medium companies (<250 employees)	Managerial roles (top executives, CEOs)
50	Male	Doctorate	Nautical furniture	Center	Small companies (<50 employees)	Managerial roles (top executives, CEOs)

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