SMEDT: AI-First Discovery of a Digital Transformation Framework for Small to Medium-sized Enterprises

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Abstract. Small to Medium-sized Enterprises (SMEs) are vital to Europe's economy but continue lagging behind larger firms in digital transformation (DT). This study identifies key SME-specific DT challenges: financial constraints, limited technical expertise, lack of strategic direction, and organizational resistance, through an AI-first literature review supported by human validation. In response, it introduces a conceptualization of the open-source SMEDT framework, which is do-it-yourself oriented and capability-driven. Designed with attention to contextual constraints such as knowledge dissemination gaps and high DT failure rates, the framework is a work-in-progress artifact for enabling self-guided transformation. The research contributes to the knowledge base on digital transformation in constrained contexts and advances the use of generative AI in early-stage design science. Future work includes advancing the SMEDT framework and its qualitative validation with SME stakeholders.

Keywords: Digital Transformation, Artificial Intelligence, SMEDT Framework, AI-First, SME.

1 Introduction

Digital Transformation (DT) is broadly defined as the use of digital technologies to create disruptions that trigger strategic responses from organizations, altering their value creation paths and managing structural changes. DT involves a shift in the role of technology in business from a support function to a core component of modern business strategy [1], [2], [3]. SMEs are the backbone of Europe's economy but often lag behind larger firms in digital transformation. The European Union defines SMEs as businesses with fewer than 250 employees and under €50 million in annual turnover (for medium-sized, or under 50 employees and €10 million for small firms) [4]. Many European SMEs, however, struggle to adopt digital solutions. According to OECD [5], SMEs' digital uptake remains slower, constrained by a range of internal and external barriers, and consistently trail larger companies in adopting more sophisticated digital solutions.

A recent study using data from 4,531 firms explicitly highlights the implementation gap: digitalization is seen as vital for SME success, yet insufficient funds, employee

resistance, lack of skilled staff, and a weak digital culture impede progress [6]. European SMEs employ approximately 65 million people, representing 66% of total employment across the EU [7]. Additionally, 99.8% of enterprises active within the EU's business economy in 2022 were micro or small, while medium-sized enterprises alone contributed 50.2% of the value added generated within the EU's business economy [8].

2 Research Objectives

The objective of the research presented here is to investigate DT in SMEs and present a tailor-made SMEDT Framework (SMEDT). Our thesis is that it should be possible to link current insights on DT-specific challenges that SMEs experience to an actionable framework that can empower SMEs to take more responsibility for their own DT. This leads us to the following Research Questions:

RQ1: What are the primary challenges that SMEs face during DT?

RQ2: How can a conceptualized SMEDT framework enable SMEs to autonomously address the identified digital transformation challenges?

To answer RQ1, an AI-first approach is taken. To answer RQ2, a conventional information systems (IS) approach is taken in theorizing what a prescriptive SME framework should address. While not proposing a fully developed framework, the research highlights key considerations and foundational elements for advancing such an approach.

3 AI-First Literature Review of DT for SMEs

Although DT presents challenges across all organizational contexts, SMEs encounter a distinct and often more acute set of barriers. We set out to systematically identify and synthesize these SME-specific digital transformation challenges. While the traditional stand-alone literature review remains a well-established methodological approach in the IS domain [11], supported by rigorous protocols and well-established guidelines, we deliberately diverge from these conventional models. Thus, the research presented here instead opted to harness the advanced natural language processing and knowledge synthesis abilities of Generative AI (GenAI) systems to dynamically guide the investigation. We adopted a novel, AI-first literature review methodology: An emerging, exploratory approach that leverages artificial intelligence to map, extract, and interpret patterns of vast knowledge resources. This methodological choice reflects both the evolving epistemic landscape of research and our intent to probe the literature with enhanced scalability, efficiency, and analytical depth.

3.1 Method: AI-First Literature Review

GenAI in literature reviews remains in its infant stages, marking a methodological shift toward semi-automated knowledge synthesis [9]. As Schryen et al. [16] observe, integrating GenAI into literature review processes offers the potential to significantly

accelerate the identification, extraction, and summarization of relevant studies, thus allowing researchers to allocate more effort toward higher-order analysis and synthesis. However, this emergent paradigm is not without limitations. Bail [10], among others, cautions that GenAI systems inherently reflect human biases, a consequence of their training on human-generated content.

There are several known GenAI limitations [11], for instance, hallucinations, where large language models produce answers that sound authoritative but may be factually incorrect or unsupported. Thus, there is an issue of biased or even false information. Another issue is outdated training data, as well as a tendency to overemphasize more established literature, which can potentially lead to a biased understanding of the topic. Another limitation is that the internal dynamics of GenAI lack transparency, as most large language commercial models are proprietary and closed-source, making them a black box. In addition, those models are also continuously updated, resulting in the instrument becoming non-deterministic in the sense that it is often unclear how they arrive at specific results. That in turn affects the reproducibility of the results, as AI models may produce different outputs when prompted again – the same prompt to the same model can yield different answers on different days [12]. The use of GenAI tools thus requires caution on the part of researchers, as results may include flaws and misleading information, and possibly non-existent references [9].

We selected the following GenAIs: ChatGPT (with Deep Research), Gemini 2.5 Pro, Claude 3.7 Sonnet, and Grok 3 (with Deepersearch) for their advanced natural language synthesis capabilities and ability to support iterative, exploratory review processes. Consensus and Semantic Scholar AI were initially chosen for their direct connection to scholarly databases and their reliable citation frameworks, but in the end they failed to process the prompt we wanted to use and were omitted from this study. We adopted a prompt approach inspired by Khalid & Witmer's four-step framework [13]. This, in turn, resulted in a structured prompt with a clear task that the GenAIs could solve:

> *"Task: Identify and rank the top seven most critical challenges in order of significance (1 = most important) that small and medium-sized enterprises (SMEs) face during digital transformation, specifically focusing on challenges distinct from those typically encountered by large enterprises.*
>
> *"For each of the seven challenges, provide:*
>
> *1: A concise explanation of why this challenge is particularly salient or acute for SMEs, including any resource-based, structural, strategic, or contextual limitations that differentiate SMEs from large firms in this regard.*
>
> *2: The top five peer-reviewed, high-quality, and highly cited academic sources that substantiate the identification of the challenge. Each source must:*

> *2.1: Be cited in APA format, including full citation, DOI link or permanent URL, and Google Scholar citation count (as of your knowledge cutoff).*
>
> *2.2: Be selected from top-tier outlets, preferably those indexed in Scopus, Web of Science, or the AIS Basket of Eight. In addition, include Google Scholar to broaden the coverage and identify highly cited or emergent research. Clearly indicate the publication outlet's ranking or relevance.*
>
> *After listing the seven challenges, include a brief synthesis paragraph addressing:*
>
> *a) How and where the sources were identified, including search strategies (e.g., Scopus, Google Scholar, Web of Science), and why the selected articles are considered academically credible (e.g., journal ranking, impact factor, citation count).*
>
> *b) The rationale for the final ordering of the challenges, highlighting your prioritization logic (e.g., frequency in literature, organizational impact, barriers to adoption, empirical severity for SMEs).*
>
> *c) Your latest training or update date—i.e., what is the most recent year/month for which your knowledge and citation data are current?*
>
> *d) Your current version?*
>
> *Please ensure you have responded to all sub-parts (1, 2, 2.1, 2.2, 3, a, b, c & d) before submitting your answer."*

Our main inclusion criteria in the prompt were coarse in the sense that they were limited to the selection of scholarly databases and repositories themselves. The limit of seven challenges was imposed to force the AIs to make decisions and synthesize themes. In a similar fashion, the five-paper limit was also imposed to sharpen the outcomes of the AI-first review, again forcing AI choices. Three additional questions were added for enhanced transparency, namely a), b), and c), giving information about the AI itself that would allow us to assess the validity of the result sets. We did not restrict our search by focusing on any single business domain or region.

3.2 Data Collection

Using the prompt above, each AI replied with a generated list (see table 1) with the summarized top seven most critical challenges SMEs face during digital transformation. The AIs offered explanations of why each challenge was particularly salient or

acute for SMEs. They supplied five peer-reviewed academic sources with references, also offering a brief synthesis paragraph addressing how the sources were identified and the rationale for the final ordering of the challenges. While Grok and Claude answered in real time without much waiting time, both ChatGPT and Gemini took several minutes to process and complete the request.

Table 1. Challenges that SMEs encounter regarding DT.

	ChatGPT 4.5 Version: Deep Research Cutoff date: 10/2024* Date accessed: 7/5/2025	Claude Version: 3.7 Sonnet Cutoff date: 10/2024 Date accessed: 7/5/2025	Grok 3 Version: Deepersearch Cutoff date: 5/2025 Date accessed: 7/5/2025	Google Gemini Version: Deep Research 2.5 Cutoff date: 5/2025 Date accessed: 7/5/2025
#	A	B	D	E
1	Limited Financial Resources	Limited Financial Resources and Investment Capacity	Lack of Financial Resources	Severe Financial Resource Constraints
2	Limited Digital Skills and IT Expertise	Lack of Digital Skills and Talent Shortage	Shortage of Digital Skills and Expertise	Lack of Specialized Digital Skills and Expertise
3	Lack of Strategic Planning and Vision	Complex Strategic Decision-making Under Uncertainty	Cultural Resistance to Change	Lack of Clear Digital Strategy and Vision
4	Organizational Culture and Change Resistance	Inadequate Digital Infrastructure and Legacy System Integration	Lack of Digital Strategy	Organizational Resistance to Change and Cultural Inertia
5	Inadequate Technology Infrastructure and Integration	Organizational Resistance and Cultural Barriers	Complexity of Technology Adoption	Dominance of Owner-Manager and Leadership Deficiencies
6	Data Analytics and Cybersecurity Challenges	Cybersecurity and Data Privacy Vulnerabilities	Cybersecurity Concerns	Difficulties with Technology Integration and Legacy Systems
7	Limited External Support and Ecosystem Engagement	External Ecosystem and Supply Chain Integration Challenges	Integration with Existing Systems	Heightened Data Security and Cybersecurity Concerns

* The system, however, has online access and can retrieve information per request.

3.3 Analysis

To ensure the reliability and academic relevance of the AI-generated insights, we employed human judgment. For each reference, we completed human verification, ensuring that the paper existed (they all did), that it indeed supported the theme claimed by the AI, and that the paper had been peer-reviewed. We achieved this by reviewing the title and abstract and conducting a full paper review when warranted by any uncertainty. Each AI synthesized seven challenges each (N = 28), as shown in Table 1. When there were conflicting results, we focused on the challenges that were found by all the AIs and in the same order or off by 1 in the in the hierarchy close to it (Table 1). The first four challenges yielded non-conflicting results. As the AIs agreed on the main challenge 1A: "Limited Financial Resources", 1B: "Limited Financial Resources and Investment Capacity", 1C: "Lack of Financial Resources", and 1D: "Severe Financial Resource Constraints", we thus thematized this finding as *Financial Limitations*. In a similar fashion, 2A-D were dubbed: *Lack of Technical Expertise and Digital Maturity*. For the third challenge, three of the AIs agreed, and the fourth had the same challenge as the fourth priority; thus, 3A, 3B, 4C, and 3D were combined into: *Lack of Digital Strategy*. The fourth challenge was slightly less clear, but we combined 4A, 5D, 3C, and 4D into *Organizational Culture and Change Resistance*. For the remaining challenges, the AIs did not agree, and although there were similarities, we chose to exclude them from our research in answering RQ2. This process reduced the number of challenges and aligned with the need for actionable insights as recommended by Guest et al. [14], allowing the subsequent discussion to focus on broader implications related to the design of an SMEDT, as addressed in RQ2.

4 Results

This section elaborates on the four primary challenges that the AI tool uncovered, that were validated by humans, and that an SMEDT framework must address.

4.1 Financial Limitations

It is well documented that SMEs face greater challenges securing financing for digital investments than larger firms [2], [15]. SMEs rely on limited cash flow or small loans and struggle to secure financing, especially without a proven track record, and they often lack the resources to navigate grant systems [16]. However, DT usually requires substantial investments that can strain budgets. This impacts SMEs relatively harder, and they can often struggle to justify digital investments when benefits are not immediate [17], whereas larger firms can afford long-term transformation projects with delayed payoffs [18]. The high upfront costs of technology also represent a disproportionate burden for SMEs, forcing them to forego investments that bigger firms can, to some extent, absorb as routine spending [19].

4.2 Lack of Technical Expertise and Digital Maturity

Many SMEs lack dedicated IT departments, making digital transformation more challenging [20]. Additionally, they lack dedicated IT staff and in-house skills to manage complex digital projects, making navigating in DTs difficult [2], [21]. With a lack of in-house technology specialists, SMEs are left at the mercy of consultants and vendors for expert guidance. A Sage research study found that 45% of SME executives cite insufficient technological know-how as a barrier [22]. This skills gap profoundly affects an SME's ability to make informed technology selections, execute implementations smoothly, leverage data for actionable insights, and maintain adequate cybersecurity, thereby hindering their overall digital transformation progress [23].

4.3 Lack of Digital Strategy

Many SMEs embark on their digital transformation journeys without a clear, well-defined strategy, a coherent roadmap, or a compelling long-term vision to guide their efforts [24]. In the absence of a guiding strategy, SMEs may adopt technologies based on market trends, competitors, or vendor sales pitches, rather than on an assessment of genuine business needs and strategic objectives. [3]. One issue is that a coherent digital strategy often necessitates business model innovation, an area where SMEs frequently struggle without adequate strategic foresight and planning [25]. Bouwman et al. [26] also assert that successful digital transformation hinges on aligning technology with business objectives, a process that SMEs again struggle to operationalize due to limited planning capacity. Thus, SMEs' IT architecture often develops organically rather than strategically. For instance, they often operate with fragmented data architectures, undermining their ability to harness information as a strategic asset, a core concern [27]. But the significant promises and true disruption offered by AI demands a structured approach to data management and governance [28].

4.4 Organizational Resistance and Cultural Barriers

A whole set of issues arises from the human side of DT. Resistance to changes within SMEs, stemming from a lack of digital range and perhaps a reluctance to alter established business practices, are relatively usual [29]. A well-known problem is that employees dislike new systems or fear job cuts, while leaders fail to sustain momentum or invest enough in training [30]. Some studies indicate that without a robust change management framework and a cultural overhaul, transformations stall, as organizational DNA resists rewiring [31]. In SMEs, daily operations often take precedence over project deliverables or learning new systems. The attitudes of owner-managers are also central to SME culture, significantly influencing the acceptance or resistance to digital change [32].

5 Conceptualizing the SMEDT Framework to Empower SMEs

To answer RQ2 and to address the findings presented in Section 4, a more conventional Information Systems (IS) approach was adopted to theorize and conceptualize the components that a prescriptive framework should contain. When we speak of a 'framework,' we adopt the term as it is used within the IS discipline [33], [34]. From this perspective, a framework is understood not as a formal theory but as a scaffold that brings coherence to a complex phenomenon by delineating core components and their interrelations. The SMEDT framework is thus intended as a design-oriented and interpretive lens that facilitates both understanding and practice, particularly in contexts where SMEs face unique technical and resource-based constraints in their pursuit of digital transformation. The proposed SMEDT framework thus represents a conceptual structure developed to organize and categorize the key challenges, enablers, and intervention mechanisms relevant to DT in SMEs. To ensure both practical relevance and conceptual validity, the framework will be evaluated through a multi-phase qualitative validation strategy spanning 2025 and 2026. While the study presented here does not propose a fully developed or finalized framework, it contributes by bringing to the surface and organizing key considerations and foundational elements necessary for shaping such an approach. Thus, the work serves both as a design artifact in progress and as a springboard for future theory development and contextual adaptation.

5.1 Contextual Constraints for the SMEDT Framework

The SMEDT framework must address the core challenges identified in Section 4, which are well-established barriers to digital transformation in the literature. However, two contextual constraints are also critical, as they surround the situation that SMEs are in. The first is a knowledge dissemination gap as SMEs often lack access to practical, affordable, and actionable guidance. Academic models, consultancy, and business literature were not made for SMEs and fail to meet their needs. Therefore, SMEDT must be grounded in SME realities, offering clear, non-technical, and stand-alone guidance that SMEs can apply independently and autonomously. The second contextual constraint takes the form of a "safety first" principle, which stems from the Financial Limitations. This constraint derives from the fact that empirical studies suggest that fewer than 10% of DT initiatives achieve their intended outcomes [35]. Large firms can, to some extent, weather failed experiments, but SMEs cannot [36]. Both constraints must be addressed in the design of the SMEDT framework.

5.2 Conceptualizing Initial Solutions Based on the Design Criteria

This section introduces initial conceptual solutions that will form the basis of the SMEDT framework. These initial solutions are explicitly crafted to address the contextual constraints while offering actionable responses to the four core challenges facing SMEs in digital transformation. The approach here is constructive but provisional, emphasizing solution logic and design intent, with the understanding that these components will be subject to iterative validation and refinement in practice. Importantly, the

proposed solutions aim to balance conceptual rigor with practical utility, ensuring that they are both theoretically sound and operationally feasible.

Addressing Financial Limitations: The SMEDT framework will be designed as a free and open-source initiative to ensure broad accessibility and adaptability for SMEs. This design decision serves a threefold strategic purpose: First, it directly mitigates the financial limitations that commonly constrain SME digital transformation efforts. Second, it enables ongoing enhancement of the framework by fostering a collaborative ecosystem of contributors, including practitioners, researchers, and policy actors. Thirdly, it promotes sustainability through continuous updates and refinements via open-access repositories or version control systems. In doing so, the framework transcends the static nature of many traditional DT models and supports the emergence of a living, evolving resource tailored to SME needs by inviting contributions. Thus, the SMEDT framework will be do-it-yourself (DIY) oriented, which again reinforces its cost-effectiveness, addressing financial limitations and the knowledge dissemination gap. Thus, SMEDT must be intuitively structured and explicitly designed to empower SME managers and employees to lead transformation efforts as independently as possible. This can be achieved by offering playbooks and tool templates, empowering the SMEs to act on the softer but foundational parts of DT.

Addressing Lack of Technical Expertise and Digital Maturity: The SMEDT framework approach is capability-centric, oriented to address the widespread challenge of limited technical expertise and low digital maturity among SMEs. This principle shifts the emphasis away from mere technology adoption toward capability building and developing organizational, human, and processual capacities necessary for sustained digital transformation. The framework operationalizes this principle by offering digital maturity assessments and progressive capability-building pathways, allowing SMEs to mature digitally at their own pace, starting with basic digital competence, progressing to digital usage, and ultimately supporting strategic digital transformation, as conceptualized in the digital literacy framework of Martin and Grudziecki [37]. Each module of the SMEDT framework is designed to address an immediate challenge and incrementally enhance the firm's capacity to understand, utilize, and innovate with digital technologies.

Addressing the Lack of Strategy: The SMEDT framework integrates a lightweight, adaptive strategy layer designed for resource-constrained and dynamic environments, addressing the pervasive absence of coherent digital strategies among SMEs. Unlike large firms, where strategic planning is institutionalized and often supported by dedicated units, SMEs typically engage in informal and reactive decision-making. This reactive posture leads to fragmented efforts, resulting in technical debt and misaligned IT architectures. To counter this, the SMEDT framework offers strategic scaffolding tools, including visioning templates, capability roadmaps, alignment checklists, and facilitation guides to run strategy workshops. The aim is to empower SMEs to conduct their own strategizing by offering resources that simplify strategy development. Notably, this will not just mimic the approach taken by larger organisations.

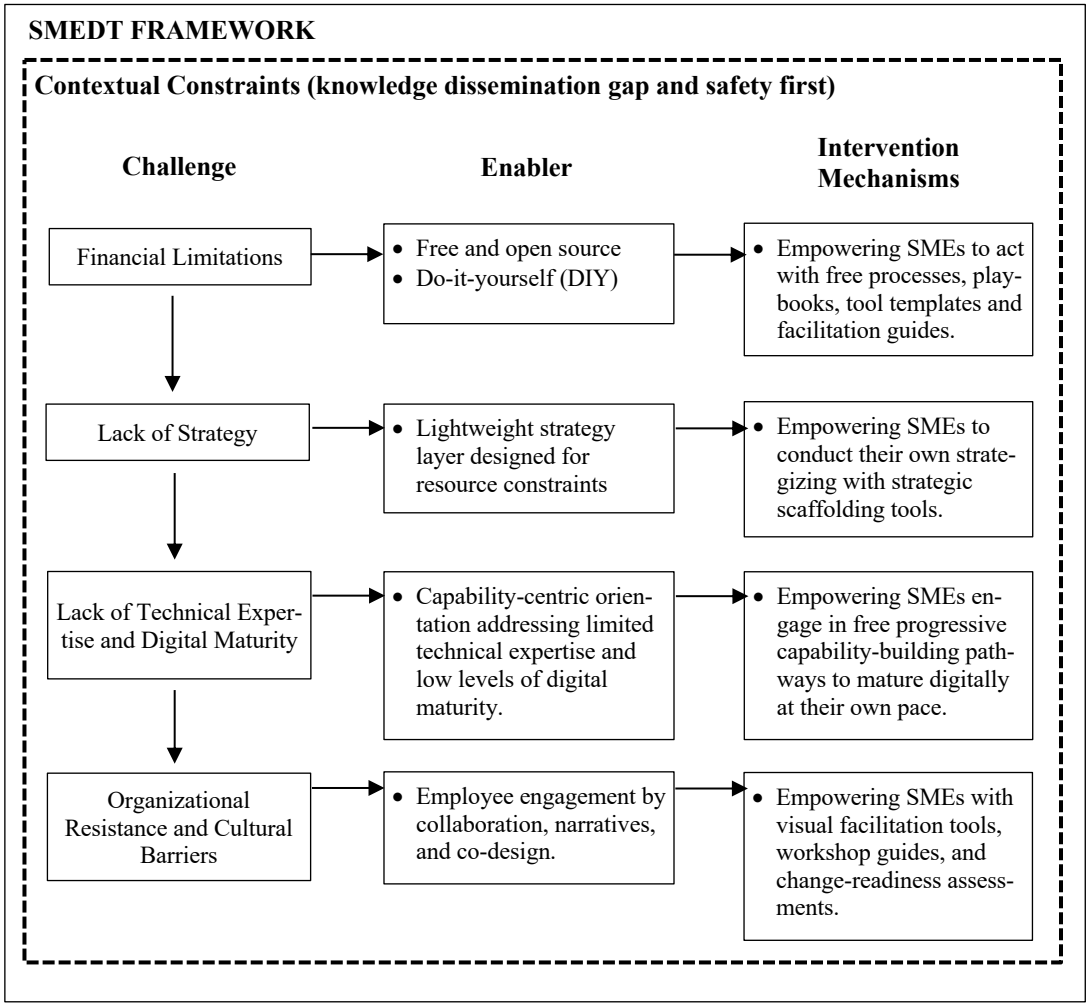

Figure 1: SMEDT Framework

From Design Criteria to Constructive Blueprint

In summary, the SMEDT framework is deliberately shaped by the realities of SMEs, where limited resources, low digital maturity, organizational resistance, and a lack of a clear strategy frequently undermine digital transformation. The framework addresses these conditions through two foundational design criteria: closing the knowledge dissemination gap and adhering to a safety-first principle. By adopting a DIY-approach and embracing an open-source delivery model, SMEDT empowers SMEs to take ownership of their transformation journeys with minimal external dependency. It provides accessible, low-cost, and non-technical guidance that enable managerial autonomy while safeguarding against the risks of poorly aligned or premature initiatives.

6 Limitations

A central limitation of this study concerns the lack of transparency in the generative AI models used to support the initial literature exploration and ideation process. While these tools demonstrated wide-reaching contextual capabilities, they function as black boxes, offering limited insight into the source or academic validity of the outputs. All references were manually verified to mitigate risks and ensure scholarly rigor. Nonetheless, consistent with observations by Walters [38], we encountered one instance of AI hallucination in the form of a generated reference to a non-existent article. In several other instances, the AI generated incorrect DOI strings, which was an unexpected error given the structured nature of such data.

7 Conclusions

This article has thus answered the two research questions stated earlier.

RQ1 was addressed through an AI-first literature review, supplemented by human validation. Four core challenges were identified by the AIs and validated: financial limitations, lack of technical expertise and digital maturity, lack of strategy, and organizational resistance and cultural barriers.

RQ2 was addressed by proposing a conceptual SMEDT framework, shaped by two key contextual constraints: a knowledge dissemination gap and a "safety first" principle, and by addressing the four core challenges.

It was concluded that SMEDT should adopt a DIY and open-source model, designed to empower SMEs to act independently, without reliance on consultants or proprietary tools. Adopting this stance would also ensure that the framework remains low-cost, for instance, by providing SMEs with strategy templates, capability pathways, and participatory change methods.

This study thus contributes to both SME DT research and the development of AI-augmented methodologies. It highlights how AI tools can accelerate early-stage design, provided that human verification governs the research effort. Similarly to other relevant methodological developments [39], [40] we will focus on developing the framework and empirically validating it through collaboration with SME stakeholders going forward.

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