# A Sustainable Digital Transformation and Management of Small and Medium Enterprises through Green Enterprise Architecture

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**Abstract**

Digital Transformation (DT) is essential for Small and Medium-sized Enterprises (SMEs) to enhance operational effectiveness, stimulate innovation, and address forthcoming issues. Incorporating sustainability into this procedure not only improves the image of a business but also draws consumers and investors who prioritize commitment to the environment. Even with this change, several SMEs need explicit objectives or strategies. The research analysis revealed an absence of frameworks that include sustainability in the DT procedure for SMEs. This article addresses the gap by including Environmental Sustainability (ES) in the discussion of DT, presenting Green Enterprise Architecture as a methodology for sustainable transformation that assesses technological maturity and enables incremental adoption by strategic goals. A thorough literature study employing the Methodi Ordinatio identified six fundamental elements of the digital shift. As a result, the Pathway was established, utilizing ISO-IEC 33000 standards to provide delineated methods for improving digital capabilities. The pathway encompasses three tiers of organizational organizing: strategic, tactical, and practical. It incorporates a maturity framework that assesses 70 activities along 6 measurements: Digital Technology, Consumer Concentration, Institutional Cultural Affairs, Organizational Management, Individuals, and Environment. A case study validated the pathway's efficacy in tackling real-world difficulties and assisting SMEs in digitalization. The Pathway offers a thorough and cohesive strategy, guaranteeing constant modification and enhancement in sustainable digital alteration initiatives. This pathway identifies a critical deficiency in research and provides a pragmatic, planned, and flexible framework for SMEs starting their DT endeavors.

**Keywords:** Digital Transformation; Small and Medium Enterprises; Sustainability; Green Enterprise.

## I. INTRODUCTION AND BACKGROUND

Digital Transformation (DT) is essential for firms to maintain competitiveness, providing advantages such as enhanced cooperation, diminished delivery period, and augmented manufacturing adaptability (Zhu et al., 2021).

DT entails the application of technologies to alter corporate operations, provide consumer value, and adjust to the digital world.

A sustainable approach throughout DT guarantees a resilient, inventive, and influential company framework that enhances ecological and societal welfare. Digitalization, via robotics, analytics of data, and Artificial Intelligence (AI) instruments, enables business to refine procedures and improve workflows systematically, possibly lowering costs while maintaining sustainable practices to reduce the planet's impact and foster social equity (Hanelt et al., 2021). This comprehensive strategy enables organizations to satisfy the requirements of more discerning customers and stringent authorities, creating new market opportunities and enhancing their standing in the marketplace. Integrating technological advancement with sustainability enables firms to generate long-term value, securing immediate economic success and enduring sustainability and accountability.

Kunkel & Matthess, characterize the digital sustainability field as the institutional endeavors to promote environmentally friendly goals through the innovative application of devices that generate, employ, transmit, or procure electronic information (Kunkel & Matthess, 2020). Digital sustainability integrates the dual strategic goals of long-term sustainability and technological change to foster beneficial social and environmental advancements.

Certain studies contend that digitization presents an optimistic perspective on sustainability potential; yet, if inadequately managed or undervalued, it adversely impacts an organization's long-term success. Digital change enhances company viability with effective corporate management and the education of personnel, which are essential factors. Additional writers propose that digitalization enhances sustainability, reduces costs, fosters revenue growth, and improves financial outcomes.

The COVID-19 epidemic has accelerated this procedure and demonstrated the imperative for SMEs to embrace viability and DT, prompting further study. The significance of Sustainable DT (SDT) for Smart and Medium-sized Enterprises (SMEs) resides in its capacity to improve efficiency in operations, foster creativity, and equip firms to adjust to swift technology advancements (Teng et al., 2022). Research suggests that SMEs must actively participate in SDT to maintain competitiveness. Despite budgetary limitations, a significant obstacle to DT is the need for comprehensive and clear pathways. Many firms need a definitive strategy, goal, and preparation for DT and long-term sustainability. The literature outlines many pathways for Industry 4.0, emphasizing the transition of Industry 4.0 principles from study to application. Customized DT pathways for SMEs are somewhat rarer. Only seven investigations in the literature include DT directions for SMEs, while five research offer plans incorporating sustainability.

Despite considerable focus on integrating sustainability into digitalization, research studies revealed an absence of pathways mainly designed for executing sustainable DT in SMEs. Several critical issues must be considered while developing a DT strategy for SMEs. Initially, the technological maturity of the SME must be evaluated, providing a basis for formulating a plan that considers its unique limitations and strengths.

Secondly, the company's long-term strategies must be explicitly articulated to guarantee that digital activities are congruent with overarching company objectives. The researchers advocate for slow and incremental enhancements in digitization to assist SMEs in adapting without overwhelming their finances.

While several DT plans in the literature integrate maturity frameworks, these frameworks are designed for something other than SMEs and need a focus on sustainability. An initial maturity model is intended to enhance digitalization in production, and the Self-Assessment Maturation Method provides a thorough framework for advancing digital maturity inside businesses (Eisner et al., 2022).

The research review reveals a distinct study disparity: the absence of SDT plans tailored for SMEs that (1) Evaluate rate of DT maturity, (2) Facilitate the slow and gradual execution of DT, (3) Correspond with long-term goals. They introduce the term Green Economic Architecture (Green EA) to denote this idea of Environmental Sustainability (ES)-enhanced EA. The author used the Generalised Enterprise Referencing Architecture and Mechanism (GERAM) as the architectural framework (Li et al., 2020). The author asserts that incorporating Enterprise Management (EM) into Enterprise Architecture (EA) effectively resolves the deficiency of EM interaction with corporate and Information Services (IS), as well as the challenge that EM efforts must be internally motivated and pervasive inside the organization to facilitate cultural transformation. A selection of EA artifacts is delineated; nonetheless, they remain theoretical and lack the necessary specificity for immediate implementation in a corporate environment.

## II. SME PATHWAY

The Pathway seeks to offer transparent and standardized procedures to assist SMEs in executing sustainable digitization. The strategy aims to rectify the deficiencies noted in the existing literature by providing a systematic framework for SDT within companies. This will be accomplished by evaluating the organization's current capabilities and maturity stages, leading to continual transformation and perpetual development. The Pathway is designed according to ISO-IEC, which outlines a systematic model comprising 3 tiers: planning, executing, and practical. ISO-IEC offers applicable directives on employing process evaluation within an extensive framework for ongoing enhancement. It provides advice on cultivating and sustaining the capabilities required to guarantee the achievement of these enhancements. Figure 1 shows the Pathway. The detailed workflow is given below:

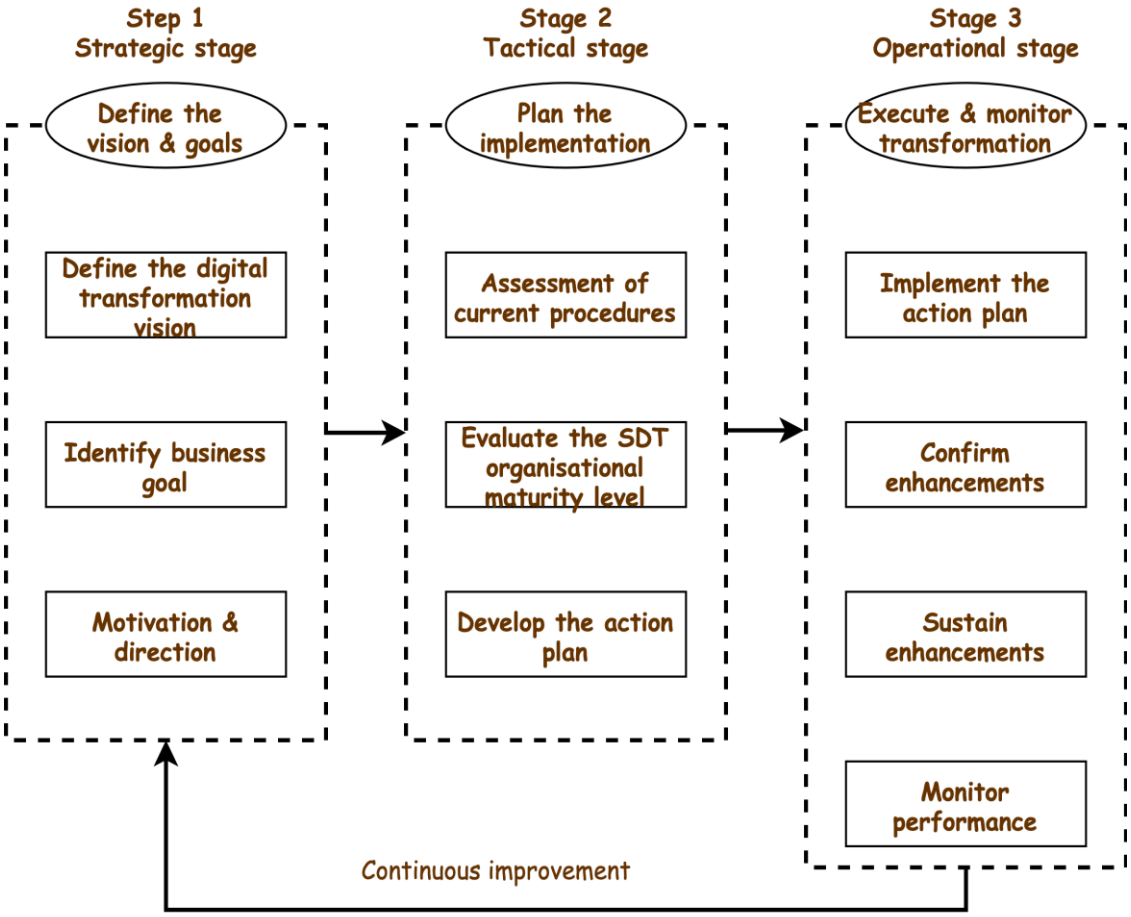


Figure 1: Pathway Model

**Step 1: Strategic Stage:** Articulate Vision and Goals

A definitive understanding of SDT for the SME should be formed immediately. This goal must fit the business's goals, like enhancing efficiency, elevating the client experience, or penetrating emerging markets. This goal establishes precise and quantifiable targets (e.g., procedure digitalization, implementation of novel techniques, or enhancement of digital competencies inside the group). After that, the impetus for DT (e.g., effectiveness, creativity, and economy) is defined, directing the firm toward its objectives.

**Step 2: Tactical Stage:** Strategize the Execution

A team inspects according to ISO-IEC 33002 to evaluate process protocols, encompassing gathering information and verification methodologies. The team gathers data via informal conversations with process managers and analyzes work deliverables, including papers, tools, and messages. After data gathering, the team evaluates the information to ascertain existing capacity levels, the advantages and disadvantages of long-term DT procedures, and the company's technological maturity grade. The capacity evaluation identifies and prioritizes possibilities for enhancement, facilitating the development of a strategy for action in the report of findings. After that, the company formulates a plan of action encompassing job packages, designated duties, and dates, considering its particular circumstances.

**Step 3: Operational Stage:** Implement and Oversee the Transformation

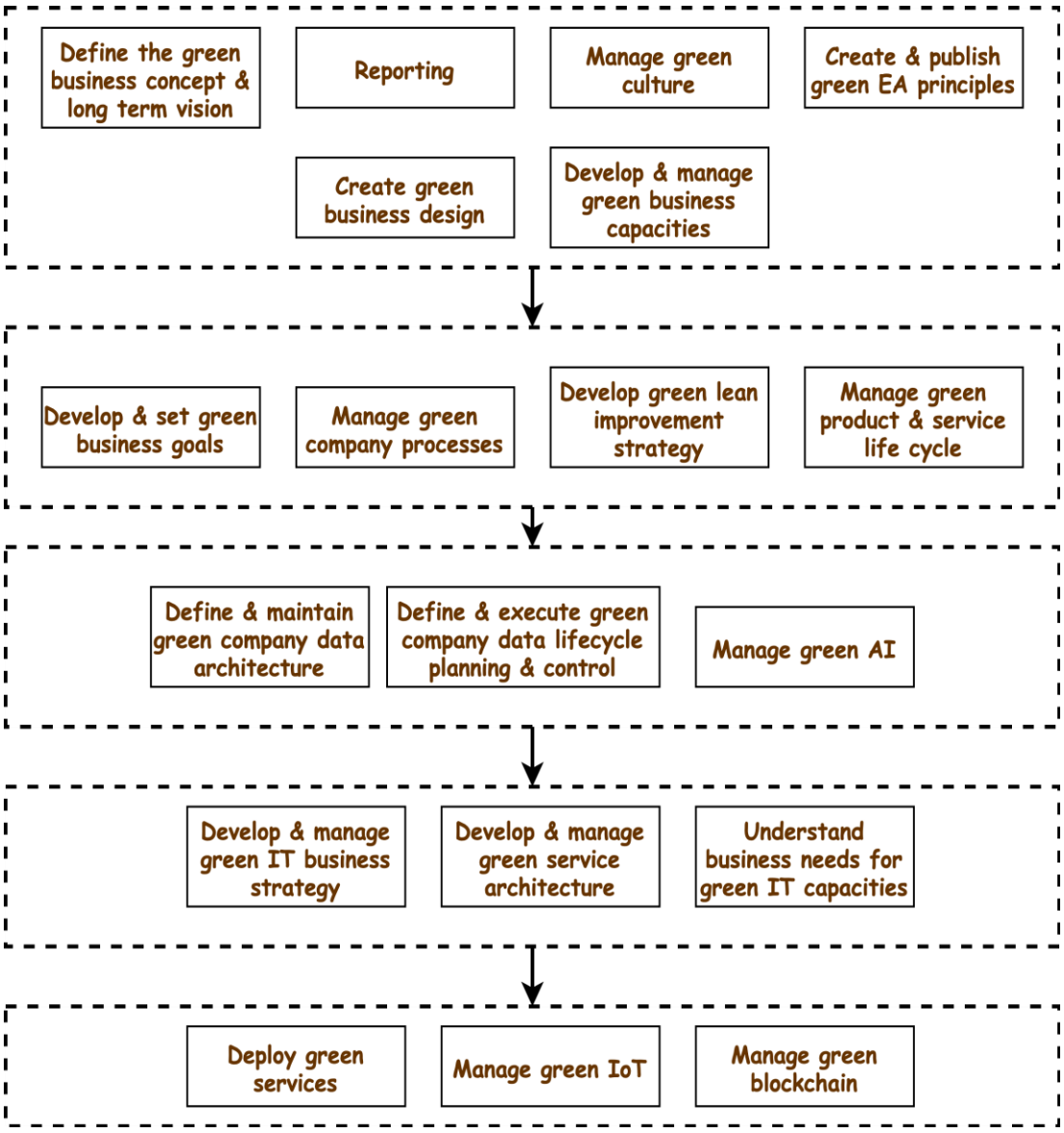


Figure 2: Green EA Capacity Mappings

This phase encompasses the execution of the action schedule, verification, and the sustainability of enhancements, constituting a long-term endeavor. Process assessment findings inform ongoing enhancement choices, ensuring that every action is grounded in empirical facts and the business's present condition. The Pathway facilitates the digitalization of SMEs while ensuring their ability to adapt and enhance. It is a comprehensive guide for strategy, tactics, and operations, ensuring that all facets of sustainable DT are tackled cohesively and effectively.

The subsequent two models integrate sustainability into corporate society and maintain consumer transparency regarding environmental sustainability. These enhance the capacity to control a green environment Figure 2.

The preceding sections examined the layout and creation of the artifact organized according to the hierarchical levels, informed by insights from scholarly and professional sources. This section delineates the suggested artifact, which comprises:

1. A collection of specific courses of action that businesses implement to integrate enterprise sustainability into each company layer: strategy, company, data, usage, and technologies.
2. A summary of the essential competencies for Green EA. These competencies can be developed to enable an organization to pursue the suggested action plans.
3. Two Capability-Based Management (CBM) instances are presented as capacity map applications, concentrating on analysis pertinent to ES objectives.

Here, the research delineates the various components of the solution artifact and guides their practical use.

### *2.1. Collection of Specific Courses of Action (CoA) and Their Correlation to the Pertinent Capabilities*

The collection of specific CoA is grounded in the current scientific research. Companies utilize the CoAs to integrate ES into every company layer (Nayal et al., 2022). The outcome summarizes the suggested Green EA characteristics and their connection to the suggested CoAs, along with supplementary activities, procedures, and responsibilities intended to enhance the implementation of these abilities. When further activities, procedures, or responsibilities about a specific capacity have yet to be addressed in this document, this is denoted as inappropriate.

### *2.2. Green Enterprise Architecture Capability Map and Use Cases*

Companies utilize this map as a fundamental instrument to direct, monitor, and govern the incorporation of these competencies. Companies seeking to use this map have many distribution techniques available. The map functions as an initial structure to identify the requirements. Considering the many stakeholders and the company's goals, judgments must be taken on whether Green competencies are critical and to what extent they are necessary. This involves the company assessing the requirement of each competence, followed by a decision to either enhance current capacity, develop new ones, or pursue acquisition/outsourcing. Moreover, the degree of ambition linked to every talent must be assessed. The aspirations vary from modest to substantial.

To realize this vision, decisions must be taken for each relevant capacity concerning the required arrangement of personnel, procedures, data, and technologies. The third step entails doing a fit-gap assessment. The goal is to evaluate and clarify the alignment of an organization's present condition with its established objectives for each capacity specified in the Green EA capability mapping, as described in the initial two processes. A gap assessment is conducted for every capacity along four categories: process, personnel, data, and applications/technology, in light of the organization's strategic ES objectives and ambitions. This study provides a detailed perspective, identifying areas of excessive investment or underutilization of each capacity's strategic goals and significance. A graphic depiction of this is available: Gap Evaluation of Green Skills. The skills marked with a dashed pattern were either altered to "green" or identified as new inclusions within the Green EA competence framework.

### *2.3. ES-Aware Corporate Capability Modeling*

The last element of the suggested remedy artifact presents an ES-aware capacity modeling technique. This strategy enhances the company's comprehensive capability mapping, which includes more than the previously outlined Green EA capacity, by incorporating a RAG (Red, Amber, Green) assessment for each capacity. This examination assesses the ecological impact, providing a detailed visual depiction of the company's Environmental Footprint (EF) employing ES-aware company strength modeling (Guliyev, 2024). The cumulative environmental effect, represented by capability, is depicted in this heatmap representation. This ES-aware company capacity modeling offers a comprehensive overview of the company's whole EF, enhancing the discourse on Green Competencies discussed in the preceding section. Both capabilities modeling methodologies can be integrated into a single map; however, the research has excluded this in the examples for simplicity.

## III. VERIFICATION OF THE PLAN: A CASE STUDY

A case study assessed the practical relevance and efficacy of the suggested Pathway in resolving the real-world difficulties encountered by SMEs. The investigation was conducted at a furniture production firm employing 47 individuals in southern Brazil. This firm functions in three primary industries: bespoke furniture manufacture, immediate delivery furniture sales, and upholstered material selling.

This enterprise is categorized as a small business by Brazilian criteria. In Brazil, SMEs are predominantly categorized according to their yearly income and, in certain instances, by staff count. The groups encompass microenterprises, which generate an annual revenue of up to R$ 360k and typically employ a maximum of nine individuals, contingent upon the nature of the business. Small enterprises generate yearly sales between R$ 360k and R$ 4,800k and employ up to 50 individuals. SMEs typically possess an annual turnover ranging from R$ 4.9 million to R$ 310 million, employing between 50 and 99 individuals. SMEs are integral to Brazilian finance, constituting the maximum firms and contributing substantially to employment generation.

Four principal individuals were talked to: the Human Resources supervisor, the production manager, the sales supervisor, and the Information Technology (IT) consultant. The cumulative period of the meetings was nearly forty minutes. This research designated the organization as the "Business X" to maintain secrecy.

### *3.1. Research Tools*

An organized questionary with ratings for assessment was used as the study tool. This section presents a rationale for each concept's selection and meaning. The research's four components (business efficiency, handling change, technological maturity, and green growth) were developed through a survey of research in strategic leadership and sustainability. The preliminary concepts were evaluated for answer scale accuracy using brief open-ended conversations with ten executive managers from various SMEs, who were queried regarding sustainable growth, handling change, and digitization. Seventeen items were developed to assess the four components based on information from the brief interviews. In the subsequent step, five specialists from the fields of business and higher education were solicited to verify the uniformity

of the articles. Only the 13 subjects upon which all experts concurred were included in the poll. The questionnaire subjects were pre-analyzed on a group of businessmen and company, followed by an initial investigation including enterprises in the area under examination.

### *3.2. Digital Maturity*

Companies across nearly all sectors have implemented various programs to use DT to enhance company efficiency and sales. The word digitalization denotes the shift from conventional business operations to the execution of company activities in a digital format. Technological maturity is the extent of a company's DT relative to its industry counterparts. This framework is crucial for assisting companies in navigating the ongoing societal and financial crises precipitated by the epidemic. The assessments were: "Compared to other companies in the field, the company's digital offerings are more sophisticated," "Relative to the opponents, the company's DT is significantly more progressed," and "The company is an innovator in DT in the sector." The scale has strong reliability (Cronbach's alpha = 0.96).

### *3.3. Business Performance*

The success of a business is determined by its most pertinent financial measures. Consistent with previous research, the poll assessed business success using three prevalent metrics: customer share, revenue-to-profit ratio, and return on capital. Consistent with previous research and due to the confidentiality of objective data, the research utilized perceptual performance indicators. Previous research indicates a strong association between what employees think and objective company performance, with perceived success occasionally demonstrating more reliability. In this study, participants are pivotal decision-makers in organizations; therefore, it is reasonable to presume they know their companies' present operating status. The perspectives of principal decision-makers are regarded as expert assessments, rooted in more intricate dimensions than objective measurement of performance. Participants conveyed their evaluation of whether these parameters had risen or fallen during the past 5 years (1 = greatly reduced, 5 = elevated). The scale has high reliability (Cronbach's alpha = 0.95).

### *3.4. Green Development*

It is characterized by a company's prospective readiness to participate in many initiatives, including expenditures in renewable energy, disposal of waste, and sustainable environmental practices. All three self-developed instruments are designed to assess the degree of a firm's commitment to investments that promote green growth. These expenditures are crucial for sustainable development and social responsibility in business. The rating items included: "The company has pledged to deposit in green vitality," "The company is dedicated to investing in waste leadership," and "The company is dedicated to investing in public sector growth initiatives in green ecological sustainability." The validity is strong (Cronbach's alpha = 0.91). The categories were assessed using a 5-point rating.

### *3.5. Examination of the Suggested Pathway*

After executing the path, the suggested Pathway was positively welcomed by the firm where it was implemented. The plan effectively identified the business's existing status and delineated a clear trajectory for DT. The amalgamation of strategical, tactical, and functional domains provides a solid and dependable basis, guaranteeing a holistic model for SDT.

Analyzing the Pathway with the pathways in the research uncovers numerous notable distinctions. The research's recommended pathway uniquely attains a higher standard throughout all six criteria established as the basis for sustainable DT in SMEs, specifically targets SMEs, and encompasses all three tiers of organizational management. These elements highlight the unique methodology of the DT in SMEs Pathway.

The research study of paths indicates a diverse focus across the six assessed characteristics. These plans often demonstrate exceptional performance in the "Digital Technology" component, attaining a significant degree of presence. The "individuals" factor is prominently featured, with specific pathways acknowledging the significance of training and staff involvement, while others handle it more restrictively. Likewise, the "Client Focus" pillar is prevalent in several pathways, underscoring the significance of client interactions for the firm. Nevertheless, the aspects of "Organizational Oversight," "Administrative Culture," and Sustainable development garnered far less focus in this collection.

The examined pathways predominantly focus on the Strategic Stage, needing more thorough coverage of the tactics and operational tiers. One path emphasizes improving SMEs' collaborative capacities using Industry 4.0 technology, targeting sustained development and resilient organizations as hallmarks of business strategy. While it discusses operational elements like implementing a data science platform, its main emphasis is on something other than everyday operations, neglecting crucial tactical specifics. Another pathway highlights evaluating SMEs' technical and economic maturity while incorporating Industry 4.0 efforts with long-term goals, but more practical direction is needed. Most examined pathways emphasize strategic planning, while strategic and operational advice differs.

Furthermore, of the examined pathways, only one incorporates a maturity approach, but in a markedly distinct manner from the approach presented in this research, as it incorporates a maturity framework inside a structure for deploying a Cyber-Physical System (CPS) design in SMEs. The study indicates that pathways targeting viability need to prioritize SMEs. Conversely, those focused on SMEs generally pay attention to long-term viability except for one pathway designed to bolster the function of Digital Innovation Hubs (DIHs) in fostering sustainable development amongst SMEs. This represents a distinct emphasis relative to the path suggested in this study.

The Pathway distinguishes itself in the field by presenting a robust and transparent methodology for enterprises, addressing deficiencies noted in other approaches, and serving as a significant asset for the SDT of SMEs. The comprehensive methods and incorporation of every planning tiers highlight the significance and efficacy of the suggested pathway, offering a resilient and flexible solution to tackle digitization problems in SMEs.

## IV. CONCLUSION

This research sought a sustainable DT pathway for SMEs that evaluates digital readiness and facilitates the progressive deployment of their strategic goals. To attain this objective, a comprehensive research study was performed utilizing the Methodi Ordinatio technique. The existing research facilitated the recognition of current DT pathways for SMEs and delineated the six essential characteristics of sustainable DT. Based on this, the Pathway was established,

utilizing the ISO-IEC 33000 as its basis. The pathway's architecture was developed by ISO-IEC 33014, which offers a systematic green framework that includes three tiers of enhancement: planning, execution, and practical.

A maturity framework was created at the tactical portion of the pathway to evaluate the organization's present stage in its sustainable DT, assessed by the potential levels of its processes. The procedures were delineated based on the six characteristics highlighted in the research: Digital Technology, Consumer Focus, Organizational Cultural Affairs, Corporate Management, Individuals, and Sustainability. This maturity framework facilitates the evaluation of the aggregate digital maturity and the particular maturity of every aspect. This multidimensional assessment assists SMEs in recognizing their strengths and regions for advancement, allowing them to focus upgrading efforts more efficiently.

A case study assessed the usefulness and efficacy of the Pathway in resolving the practical difficulties encountered by SMEs. The research validated the practical utility of the Plan, illustrating its effectiveness in enabling companies to evaluate their existing digital competence, pinpoint particular competencies for enhancement, and execute DT efforts progressively and strategically. The capacity levels provide a definitive framework for assessing maturity across six essential characteristics, enabling a more targeted strategy for improving digital competencies.

It is crucial to recognize several limitations of this research. Although the pathway demonstrated efficacy in the examined setting, its use in different sectors, geographies, or organizational types encounter distinct problems not considered in this research. The established maturity model necessitates modifications to accommodate the particularities of several economic sectors, including commerce, offerings, and business, representing a significant avenue for future study. The integration of developing technologies warrants consideration, as it might enhance the pathway's significance in a swiftly changing digital environment.

The Pathway can affect the SME ecosystem and the overall DT scenery, providing a pragmatic and strategic instrument for companies across diverse industries. This pathway aligns digital projects with strategic goals and adapts to each company's specific environment, establishing itself as an essential instrument in the continuous quest for digital excellence. In summary, the Pathway fills a notable void in the field and provides a pragmatic, strategical, and flexible framework for the DT of SMEs. Its versatility and connection with business goals, along with an understanding of the unique requirements of SMEs, provide it a crucial instrument for tackling the problems of DT in the contemporary corporate landscape.

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