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TOE-FRAMEWORK IN AI ADOPTION: A QUALITATIVE ANALYSIS OF SICILIAN SMES

This research examines the enablers and barriers to artificial intelligence (AI) adoption among small and medium-sized enterprises (SMEs) in Sicily, foregrounding how technological, organizational, and environmental factors interact in a peripheral regional context. Adopting a qualitative design, we conducted eight semi-structured, in-depth interviews with managers from digitally oriented and traditional SMEs. Data were analysed abductively through the Technology-Organization-Environment (TOE) framework. Findings reveal a pronounced

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КОНЦЕПЦІЯ TOE У ВПРОВАДЖЕННІ ШІ: ЯКІСНИЙ АНАЛІЗ СИЦИЛІЙСЬКИХ МАЛИХ ТА СЕРЕДНІХ ПІДПРИЄМСТВ

Це дослідження аналізує фактори, що сприяють та перешкоджають впровадженню штучного інтелекту (ШІ) серед малих та середніх підприємств (МСП) на Сицилії, висвітлюючи взаємодію технологічних, організаційних та екологічних факторів у периферійному регіональному контексті. Використовуючи якісний дизайн, було проведено вісім напівструктурованих глибоких інтерв'ю з менеджерами цифрових та традиційних МСП. Дані були проаналізовані за допомогою моделі "Технологія-Організація-Середовище" (TOE). Результати дослідження виявляють яскраво виражену різницю: цифрові МСП



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divide: digital SMEs treat AI as a strategic asset already embedded in daily workflows (e.g., code analysis, marketing, administrative support), reporting productivity gains and a shift toward higher value-added tasks; while traditional SMEs view AI as distant or overly complex, citing low awareness and unclear use cases. Organizational culture and leadership are pivotal—entrepreneurial, experimentation-friendly settings (often with dedicated "creative technologist" roles) accelerate adoption, whereas resistance among incumbent staff and weak change communication hinder progress. Environmental constraints specific to Sicily—fragmented incentives, uneven digital infrastructure, and limited knowledge networks—further dampen uptake, creating a risk of widening digital divides. The research offers actionable implications: staged, use-case-driven pilots with clear governance; leadership development and internal champions; continuous, modular training; and ecosystem interventions (innovation hubs, cluster initiatives, targeted vouchers/grants). Theoretically, we advance a socio-technical view of AI consolidation that links micro-organizational dynamics with territorially embedded conditions. Overall, the research contributes context-sensitive evidence and practical guidance to foster inclusive AI-enabled transformation in SMEs.

Keywords: Artificial Intelligence, SMEs, TOE-framework, digital transformation, qualitative research, regional innovation.

JEL Classification: O33, L26, M15.

розглядають ІІІ як стратегічний актив, який вже інтегрований у повсякденні робочі процеси (наприклад, аналіз коду, маркетинг, адміністративна підтримка), повідомляючи про підвищення продуктивності та перехід до завдань з вищою доданою вартістю; тоді як традиційні МСП вважають ІІІ віддаленим або надто складним, посилаючись на низьку обізнаність та нечіткі випадки використання. Організаційна культура та лідерство мають вирішальне значення – підприємницьке середовище, сприятливе для експериментів (часто з виділеними ролями "креативних технологів") прискорюють впровадження, тоді як опір серед діючих співробітників та слабка комунікація змін гальмують прогрес. Обмеження, характерні для Сицилії – фрагментовані стимули, нерівномірна цифрова інфраструктура та обмежені мережі знань, – це більше гальмують впровадження, створюючи ризик поглиблення цифрового розриву. Дослідження пропонує практичні рекомендації: поетапні пілотні проекти, орієнтовані на конкретні випадки використання, з чітким управлінням; розвиток лідерських якостей і внутрішніх лідерів; безперервне модульне навчання, а також втручання в екосистему (інноваційні хаби, кластерні ініціативи, цільові ваучери/гранти). Теоретично автори просувають соціально-технічний погляд на консолідацію ІІІ, який пов'язує мікро-організаційну динаміку з територіально вбудованими умовами. В цілому, дослідження надає контекстно-залежні докази та практичні рекомендації для сприяння інклюзивній трансформації малих і середніх підприємств за допомогою ІІІ.

Ключові слова: штучний інтелект (ІІІ), малі та середні підприємства, структура TOE, цифрова трансформація, якісне дослідження, регіональні інновації.

Introduction

In the actual digital world, Artificial Intelligence (AI) is escalating in interest (Ho et al., 2022), often regarded as the Fourth Industrial Revolution (Zhang et al., 2021). Academic work (Khalid, 2020; Dwivedi et al., 2021) portrays AI as a domain that merges computer science with extensive data, enhancing corporate decision-making. Dwivedi et al. (2021) state that AI replicates human cognitive processes using advanced tools like machine and deep learning. Scholarship (Awan et al., 2021; Sestino and De Mauro, 2022) confirms its synergy with Big Data analytics to convert raw data into actionable insights.

AI implementation yields multiple benefits: lower costs, greater accuracy (Agarwal et al., 2021), higher productivity (Acemoglu and Restrepo, 2018), enhanced product development (Babina et al., 2024), and accelerated business growth (Bag et al., 2021). Consequently, organizations are

increasingly deploying AI to bolster performance (Mikalef & Gupta, 2021), despite considerable obstacles (Yu et al., 2020). The strategic ramifications of AI are a vital research area (Sun & Medaglia, 2019), as its integration influences both financial and non-financial outcomes for Small and Medium-sized Enterprises-SMEs – (Baabdullah et al., 2021; Badghish & Soomro, 2024).

SMEs are principal drivers of economic growth (Gherghina et al., 2020) and are known for their agility and adaptability to technological shifts (Baeshen et al., 2021). They are increasingly using transformative technologies to scale operations (Rawashdeh et al., 2023). Despite these advantages, SMEs encounter barriers, including internal resistance, complexity, financial limitations (Venkateswarlu et al., 2022; Bakhtiari et al., 2020), and localized factors (Schwaeke et al., 2024).

This research focuses specifically on SMEs in Sicily, a region with a unique socio-economic context. Our purpose is to evaluate AI adoption by examining the awareness and requirements of local entrepreneurs. In particular, the objective of this research is to investigate the awareness, perceptions, and needs of entrepreneurs from Sicilian SMEs in relation to AI technologies and to identify the technological, organizational, and environmental factors that affect their readiness to adopt AI solutions.

We employ the Technology-Organization-Environment (TOE) (Baker, 2011) framework to propose a conceptual model that explains firm readiness for AI and its impact on performance within this specific setting.

1. Methodology

A qualitative approach was adopted, based on eight in-depth interviews with managers from both digital and traditional SMEs operating in Sicily. Data were analyzed using the Technology-Organization-Environment (TOE) framework to identify adoption drivers and barriers.

1.1. Research design and context

A qualitative design was adopted to generate an in-depth, contextually grounded understanding of enablers and barriers to AI adoption among small and medium-sized enterprises (SMEs) operating in Sicily. We conducted eight semi-structured, in-depth interviews with managers from both digital (e.g., software/IT services) and traditional sectors (e.g., construction equipment, manufacturing). The Technology-Organization-Environment (TOE) framework guided both data collection and analysis.

1.2. Research design and context

We used purposive, maximum-variation sampling to capture heterogeneity across sectors, firm sizes, and roles relevant to AI-related decision making. Inclusion criteria were: (i) SME status per EU definition; (ii) primary

operations in Sicily; (iii) managerial responsibility for technology, operations, or strategy; and (iv) at least nascent exposure to AI concepts or tools.

Participants were recruited via industry associations, professional networks, and snowball referrals. Initial invitations were sent by email with an information sheet; follow-ups were conducted by phone to confirm eligibility and schedule interviews. Recruitment continued until thematic sufficiency was indicated.

Participants provided informed consent prior to data collection and were reminded of their right to withdraw at any time. Data were anonymized; identifiers (name of the interviewed, and firm names) were replaced with codes. Only the research team had access to audio files and transcripts.

1.3. Data collection

Interviews were conducted between May and July 2025, either on-site at company premises or via secure video-conferencing (e.g., Microsoft Teams or Google Meet), according to participant preference. Conversations followed a semi-structured guide organized around four domains: company profile, digital maturity, current AI usage and perceptions, and perceived barriers/facilitators to adoption (aligned to TOE dimensions).

Interviews lasted approximately 60–90 minutes. With written informed consent, interviews were audio-recorded and supplemented with field notes on context, emergent topics, and nonverbal cues (for in-person sessions). Recordings were professionally transcribed verbatim in the original language (Italian). Where excerpts are reported in English, they were translated by a bilingual researcher to preserve meaning and tone.

Thematic saturation was assessed iteratively; by the eighth interview, no substantively new codes emerged within TOE dimensions and subsequent analysis showed increasing redundancy across cases, indicating adequacy of the sample for the study aims.

1.4. Data collection

We employed an abductive, framework-informed thematic analysis. First, an initial codebook was developed deductively from the TOE framework (technology, organization, environment) with provisional subcodes (e.g., perceived usefulness, compatibility, data readiness; leadership, culture, skills; regulatory pressure, ecosystem support), while allowing inductive codes to capture unanticipated themes (e.g., territorial embeddedness, vendor dependency).

Two researchers independently coded the same subset of transcripts in ATLAS.ti, discussed discrepancies, and refined code definitions to enhance coherence and transparency. The remaining transcripts were coded with the stabilized codebook, with periodic peer debriefs to interrogate emerging interpretations. The final themes are reported along TOE dimensions, distinguishing adoption drivers and barriers and illustrating mechanisms with anonymized quotations.

2. Results

The findings from the eight in-depth interviews revealed a clear divide between digitally oriented and traditional SMEs regarding the adoption and perception of AI. Among the more innovation-driven companies, AI tools were not only well known but actively integrated into daily business operations across various functions, from software development and marketing to creative production and internal administration. Participants from these firms described AI not as a threat or a tool for future use, but as a strategic asset already enhancing their productivity, accelerating workflows, and enabling a more meaningful engagement with complex creative and analytical tasks. One entrepreneur observed, "*We use it in various contexts – for code analysis, client quote evaluations, document summarization*" (Interviewee 6), highlighting the practical, day-to-day utility of these technologies.

Another emphasized the transformative role of AI in their work routines, stating, "*It speeds things up enormously... we spend less time on stupid tasks and more on what really matters*" (Interviewee 3), underscoring the shift toward a more value-added work model. In stark contrast, interviewees from more traditional SMEs reported a significantly lower level of technological awareness and application. For these companies, AI was often perceived as a distant or overly complex innovation, disconnected from their immediate operational needs and day-to-day challenges. A respondent openly admitted, "*I am aware of my lack of knowledge... I wouldn't even know how to apply it in my daily work*" (Interviewee 8), reflecting a widespread uncertainty and reluctance to engage with AI technologies. This sentiment reveals a profound knowledge gap that goes beyond simple lack of access, suggesting a fundamental disconnect between the perceived benefits of AI and the practical needs of these enterprises.

Organizational culture emerged as a critical determinant in the adoption process. In digital firms, an entrepreneurial and forward-thinking leadership style fostered a proactive attitude toward experimentation. These leaders not only encouraged the use of new tools but also created dedicated roles, such as a "Creative Technologist", to guide and evangelize AI integration within the company. This approach promoted a culture of continuous learning and adaptation. Conversely, more conventional businesses faced significant internal resistance, particularly from older staff members who were skeptical of change. As one interviewee noted, "*Some colleagues are just afraid of change. They think AI will make things more complicated, not easier*" (Interviewee 1). This resistance highlights the human element of digital transformation, where fear of the unknown and inertia can be as formidable an obstacle as technological or financial limitations.

Even among the more advanced firms, the fast pace of technological evolution presented challenges. One participant reflected, "*We need weekly updates... the tools evolve faster than our ability to adapt*" (Interviewee 4), demonstrating that even those who embrace AI must constantly invest in skills and training to keep pace.

Finally, the environmental context – especially the regional characteristics of Sicily – proved highly influential. Several respondents cited the lack of public incentives, weak infrastructure, and limited access to knowledge networks as major obstacles to innovation. These external factors create a difficult landscape for SMEs trying to embrace new technologies. As one entrepreneur remarked, "*Here in Sicily, we can't wait for the system to help – we must adapt ourselves*" (Interviewee 7), a quote that captures the spirit of resilience born from a lack of institutional support. The combined effect of these external constraints and internal challenges has led to a fragmented adoption landscape, where only the most forward-thinking SMEs appear equipped to harness the full potential of AI. One participant aptly captured this sentiment, warning of a coming divide: "*This revolution is enormous and definitive. Either you keep up, or you disappear*" (Interviewee 3).

These insights underscore the importance of viewing AI adoption not solely through a technological lens, but as a multifaceted process shaped by organizational culture and regional context. The variability in readiness and usage patterns among Sicilian SMEs reveals the need for tailored interventions, including targeted training, leadership development, and supportive policy frameworks, in order to ensure a broader and more inclusive integration of AI technologies.

The following *Table 1* distills qualitative insights from eight in-depth interviews with managers of Sicilian SMEs, contrasting digitally oriented and traditional firms across the Technology-Organization-Environment (TOE) dimensions. For each theme, it reports observed evidence by firm type, representative quotations that exemplify recurrent patterns, and actionable implications. The table highlights a marked divide in AI awareness, use, and strategic framing; the role of leadership, culture, and skills in shaping adoption trajectories; and the influence of environmental factors such as infrastructure, incentives, and knowledge networks. Together, these findings depict an uneven adoption landscape in which digitally mature SMEs leverage AI to streamline workflows and elevate value-added tasks, while more traditional firms face knowledge gaps, resistance to change, and limited ecosystem support. The implications column translates these insights into targeted interventions – ranging from awareness-building and change management to training, governance, and policy measures – intended to broaden and accelerate AI uptake in resource-constrained contexts.

Table 1

AI Adoption in Sicilian SMEs (TOE-Aligned)

Theme (TOE)	Digital SMEs – Evidence	Traditional SMEs – Evidence	Representative Quotes	Actionable Implications
AI Awareness & Current Usage (Technology)	High awareness; AI integrated across functions (code review, marketing, creative, admin). AI framed as strategic asset already in use	Low awareness; AI perceived as distant/complex; unclear practical applications	"We use it in various contexts—for code analysis, client quote evaluations, document summarization" (Int. 6); "I wouldn't even know how to apply it in my daily work" (Int. 8)	Targeted awareness-building; sector-specific use cases and demos to translate abstract benefits into concrete workflows
Perceived Value & Productivity (Technology)	AI accelerates processes, reduces rote tasks, frees time for higher-value work	Benefits remain abstract; fear of inefficiency or added complexity	"It speeds things up enormously... we spend less time on stupid tasks and more on what really matters" (Int. 3)	Show ROI through pilots; start with quick wins that automate low-value tasks
Organizational Culture & Leadership (Organization)	Entrepreneurial leadership; experimentation encouraged; dedicated roles (e.g., "Creative Technologist")	Conservative culture; change skepticism, especially among older staff	"Some colleagues are just afraid of change... They think AI will make things more complicated" (Int. 1)	Leadership development for digital transformation; internal champions; change management and communication plans
Skills, Training & Pace of Change (Organization/Technology)	Continuous upskilling needed; struggle to keep pace with fast-evolving tools	Foundational digital/AI literacy gaps; limited training routines	"We need weekly updates... the tools evolve faster than our ability to adapt" (Int. 4)	Modular training curricula; microlearning; vendor-supported enablement; time-bounded learning sprints
Internal Resistance & Human Factors (Organization)	Lower resistance due to culture of experimentation; clearer narratives on value	High resistance/inertia; fear of the unknown and job disruption	"Some colleagues are just afraid of change" (Int. 1)	Address anxieties; participatory design; involve skeptics early; emphasize augmentation, not replacement
Infrastructure, Incentives & Policy (Environment)	Operate despite weak external support; rely on internal initiative	More affected by lack of incentives, weak infrastructure, limited access to knowledge networks	"Here in Sicily, we can't wait for the system to help – we must adapt ourselves" (Int. 7)	Policy support for SME AI adoption; local innovation hubs; grants/vouchers; improved digital infrastructure
Ecosystem & Knowledge Networks (Environment)	Better connected to communities, vendors, and learning resources	Sparse networks; isolation from best practices and peer learning	Implicit across interviews (limited networks reported by several respondents)	Broker connections; cluster initiatives; peer cohorts; partnerships with universities and providers

End of Table 1

Theme (TOE)	Digital SMEs – Evidence	Traditional SMEs – Evidence	Representative Quotes	Actionable Implications
Adoption Landscape & Digital Divide (Cross-cutting)	Poised to harness AI's potential; see AI as non-optional for competitiveness	Risk of falling behind; fragmented readiness and uptake	"This revolution is enormous and definitive. Either you keep up, or you disappear" (Int. 3)	Segmented interventions; prioritize lagging sectors with tailored roadmaps and support
Strategic Framing & Use-Case Selection (Organization/Technology)	Clear strategic framing; AI mapped to value-adding tasks and roles	Lack of strategic framing; unclear entry points; overwhelm from tool variety	"AI... a strategic asset already enhancing productivity" (synthesis from multiple interviews)	Use-case portfolio design; start small, scale fast; governance for tool selection and data readiness

Source: authors' elaboration.

3. Discussion and conclusion

This research provides a detailed account of how AI adoption unfolds within SMEs in a distinctive regional context like Sicily, offering valuable insights that reach far beyond local specifics. The main contribution is to demonstrate that the integration of AI is not a uniform or linear process but is profoundly influenced by regional socio-economic dynamics, the internal organizational culture of the firm, and its specific sectoral characteristics.

The application of the Technology-Organization-Environment (TOE) framework revealed that a firm's digital maturity and its managers' attitudes are decisive factors. For digitally advanced firms, these elements act as powerful enablers, allowing them to effectively translate AI opportunities into practical, day-to-day applications. Conversely, for more traditional enterprises, these same factors serve as significant barriers, creating substantial hurdles to adoption. From a theoretical perspective, this study emphasizes the critical importance of situating digital transformation research within specific territorial ecosystems.

The findings strongly suggest that regional conditions, such as the availability of training resources, the presence of supportive networks, and entrenched sectoral inertia, play a crucial and often underestimated role in shaping a company's readiness to adopt new technologies. In this sense, the research refines the TOE framework by highlighting the considerable influence of local embeddedness on technology adoption pathways.

On a practical level, the findings indicate that managerial interventions and public policies aimed at fostering AI adoption cannot be based on a "one-size-fits-all" approach. The observed heterogeneity among Sicilian SMEs necessitates the development of differentiated strategies. While digitally advanced enterprises may require sophisticated and structured training programs and ethical guidelines for responsible AI use, traditional sectors need more foundational initiatives. These should focus on raising basic awareness, demystifying AI, and reducing the ingrained resistance to change.

Innovation hubs and training institutions should, therefore, design multi-layered support systems that align with the varying degrees of digital maturity across the Sicilian SME population. The broader implication is that for SMEs, AI adoption is not just a matter of technological availability but also a process of profound cultural adaptation and organizational learning. Companies that successfully combine an openness to experimentation with deliberate investments in human capital will be better positioned to leverage AI for enduring innovation and enhanced competitiveness. Conversely, ignoring these crucial socio-organizational dimensions risks irrevocably widening the digital gap between advanced and lagging firms.

4. Implications and future research directions

This study contributes to the literature on digital transformation in SMEs and offers actionable guidance for managers, policymakers, innovation hubs, and training institutions. The findings underscore that the core challenge for SMEs is not merely adopting AI tools but embedding them into organizational routines in ways that enhance collective capabilities and elevate the value of work. The Technology-Organization-Environment (TOE) lens reveals a pronounced divide between digitally oriented and traditional firms: the former treat AI as a strategic asset already integrated into daily workflows, while the latter perceive it as distant, complex, and difficult to operationalize. This asymmetry is amplified by organizational culture and leadership – entrepreneurial, experimentation-friendly environments accelerate uptake – alongside environmental constraints specific to Sicily, including weak incentives, patchy infrastructure, and limited knowledge networks.

Managerially, the results point to a staged, use-case – driven approach. Firms should begin with "quick wins" that automate low-value tasks and demonstrate tangible ROI, then scale to more complex applications under explicit governance for tool selection and data readiness. Leadership development is pivotal: appoint internal champions (e.g., "creative technologists"), invest in change management and transparent communication, and frame AI as augmentation rather than replacement to reduce resistance – especially among older staff. Given the rapid progress of technological change, continuous capability-building is essential; modular curricula, micro-learning formats, and vendor-supported enablement can help teams keep pace without disrupting operations.

For the support ecosystem, implications are equally concrete. Innovation centers and business associations can broker access to sector-specific exemplars and peer cohorts, reducing isolation and shortening learning curves for traditional SMEs. Policy actors can mitigate environmental frictions through targeted instruments – SME vouchers or grants for pilot projects, tax credits tied to training outcomes, and investments in digital

infrastructure. Regionally rooted initiatives (local hubs, university – industry partnerships, cluster programs) can thicken knowledge networks and provide durable scaffolding for adoption, moving beyond one-off workshops toward sustained communities of practice.

Overall, theoretically, the study advances an integrated view of AI adoption as a socio-technical process shaped by the interaction of technological affordances, organizational culture and leadership, and territorially embedded conditions. Practically, it translates this view into a portfolio of tailored interventions: awareness-building with concrete use cases; leadership and change-management development; iterative pilots with clear governance; continuous, stackable training; and ecosystem-level supports that lower coordination and capability gaps.

Future research could extend these insights through longitudinal and cross-regional comparisons, examining how combinations of managerial practices and ecosystem supports enable durable consolidation of AI in diverse socio-economic environments.

Moreover, to extend and triangulate these qualitative insights, future research could incorporate a complementary quantitative phase using a survey administered to a probability sample of Sicilian SMEs drawn from the AIDA database (Analisi Informatizzata delle Aziende) – a comprehensive commercial information platform covering Italian firms. The sampling frame would consist of limited liability companies headquartered in Sicily that meet the EU definition of an SME (i.e., < 250 employees and either ≤ EUR 50 million in annual turnover or ≤ EUR 43 million in total assets). Recruitment could proceed via verified email and phone contacts listed in AIDA, with multi-wave reminders and mixed-mode administration to reduce nonresponse.

The survey grounded in the TOE framework and refined from the interview themes – would measure perceived AI utility, readiness (skills, data, governance), leadership and culture, environmental pressures/supports, and adoption outcomes; established multi-item scales would be adapted and pretested, followed by translation/back-translation and cognitive probing to ensure content validity. This design would offer a robust quantitative complement to the depth achieved qualitatively.

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