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ICT-Empowered SMEs
Foresight Research and Practice Exchange of Digital Transformation

Powering SMEs to Ride the ICT Wave

▶ **Foresight Research Brief of Digital Transformation: ICT Empowered SMEs**

CAICT-GAC & BIFNC-RAC Foresight Research Brief

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Acknowledgment and Disclaimer   »

Executive Summary »

Small and Medium-sized Enterprises (SMEs) stand at the forefront of inclusive economic growth, yet their digital transformation journey remains hampered by a persistent "Triple Divide" in technology access, financing, and skills. This foresight research brief analyses the signals in the environment to presents a strategic pathway to overcome barriers and usher in an "Inclusive Digitalization Era". Through a comprehensive analysis of global trends and stakeholder insights, this report translates visionary scenarios into an actionable, phased roadmap.

The digitalization of SMEs is not merely a technological upgrade but a systemic challenge. Our analysis reveals that isolated interventions yield limited results. Success requires a coordinated approach that simultaneously addresses the interconnected deficits in infrastructure, capital, and human capital. The strategic imperative is to move from fragmented support measures to an integrated ecosystem that enables SMEs to harness digital tools as easily as utilities and improves internal management, expands market orders, and secures financing based on their data-driven performance.

The proposed pathway unfolds across five sequential yet overlapping phases, each building upon the previous to create a virtuous cycle of empowerment. The journey begins with establishing foundational digital infrastructure and literacy (Phase 1), crucial for building confidence and basic capability. This foundation enables the activation of a diversified financial ecosystem for digital transformation (Phase 2), where innovative, data-driven lending models replace traditional collateral-based constraints. With funding and fundamentals in place, the focus shifts to deep, sector-specific integration (Phase 3), fostering data-interconnected value chains and collaborative innovation. The subsequent phase optimizes the ecosystem itself (Phase 4), refining adaptive governance and ethical frameworks to ensure long-term sustainability. The journey culminates in stimulating endogenous growth (Phase 5), where market forces and peer-to-peer value sharing drive continuous innovation and scale, embedding a digital-first culture within the SMEs landscape.

Realizing this vision demands a concerted effort from all stakeholders. Governments must prioritize coherent policy frameworks and digital public goods. Financial institutions need to innovate their risk assessment models to value digital assets. Technology providers should offer affordable, interoperable solutions tailored for SMEs. Most importantly, SMEs themselves must embrace a strategic commitment to upskilling and collaboration. By aligning their efforts along this roadmap, stakeholders can collectively transform the "Triple Divide (technology access, financing, skills)" into a bridge toward a resilient, inclusive, and digitally empowered future for SMEs worldwide.

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1.INTRODUCTION

▶ 1.1. Futures thinking and strategic foresight

Futures thinking is the discipline of systematically exploring how change might unfold across multiple possible paths. It invites us to step beyond conventional projections and imagine a spectrum of plausible futures shaped by emerging trends, disruptive technologies, and shifting societal values. Strategic foresight applies this thinking in a structured, decision-oriented manner. It transforms uncertainty into insight by blending analytical rigour with creative exploration, enabling policymakers and innovators to make informed, adaptive choices in the present. Rather than seeking to predict a single outcome, these approaches help us to ask deeper questions: What forces are shaping the horizon? Which uncertainties matter most? And what choices today could open or close pathways tomorrow? In essence, strategic foresight equips institutions, governments, and communities to recognise signals of change early, test assumptions, and design strategies that remain resilient under a range of future conditions. It expands our collective field of vision—so that decisions taken now are both purposeful and future-ready.

We live in an age of rapid technological disruption, climate uncertainty, and shifting demographics—an increasingly volatile, uncertain, complex, and ambiguous (VUCA) world that demands more than reactive planning. Futures thinking offers a structured way to anticipate change, challenge assumptions, and uncover opportunities before they surface. By shifting focus from prediction to preparedness, it equips decision-makers to test strategies against multiple futures, build resilience, and align innovation with sustainable, inclusive outcomes. Through tools such as horizon scanning and scenario building, foresight transforms complexity into clarity—turning long-term planning into a continuous, adaptive process that evolves with emerging knowledge and changing realities.

▶ 1.2. Methodology

This report applies the methodology outlined in ITU's Playbook on Strategic Foresight, leveraging its structured, participatory approach to explore signals of change, map key drivers, and co-create plausible future scenarios. Grounded in systems thinking, design thinking, and futures thinking, the process guided the identification of uncertainties, opportunities, and strategic options, ultimately translating foresight insights into actionable pathways for inclusive and sustainable digital transformation.

2. OBJECTIVE OF THE FORESIGHT RESEARCH BRIEF

This foresight research brief is designed to address a critical research and policy challenge: the persistent gap between the transformative potential of digital technologies and the capacity of Small and Medium-sized Enterprises (SMEs), particularly in developing and transitional economies. It is designed as a strategic compass for policymakers, industry leaders, financial institutions, and SMEs advocates navigating the complex landscape of digital transformation. Its primary purpose is to move beyond a generic recognition of the challenges faced by SMEs and to provide a concrete, actionable framework for enabling their successful adoption of Information and Communication Technologies (ICTs).

More specifically, this brief aims to achieve the following interconnected goals:

- **To Systemically Diagnose the Core Challenges:**
Moving beyond symptomatic analysis, this brief aims to provide a diagnostic framework that reveals the systemic and interconnected nature of the barriers facing SMEs—spanning technology access, financing, and digital skills. It seeks to model how deficits in one area exacerbate challenges in others, creating a self-reinforcing cycle of exclusion.

- **To Map Critical Drivers and Their Interdependencies:**
Through rigorous environmental scanning and stakeholder engagement, the research identifies and analyzes the key technological, economic, social, and policy drivers shaping the SMEs digitalization landscape. A primary objective is to elucidate the dynamic interactions and feedback loops between these drivers, providing a systems-level understanding essential for effective intervention.

- **To Explore Plausible Scenarios and Identify a Strategic Pathway:**
The brief employs scenario planning to chart a range of plausible futures, from fragmented and exclusionary outcomes to cohesive and inclusive growth. Based on this exploration, it defines a preferred scenario and delineates the strategic pathway necessary to achieve it, thereby translating analytical insights into a coherent theory of change.

- **To Develop a Phased and Actionable Roadmap:**

A central objective is to translate strategic vision into practical action. The brief constructs a dynamic, five-phase roadmap that sequences interventions logically—from building foundational capacities to stimulating endogenous growth. This roadmap is designed to guide stakeholders in prioritizing efforts and understanding the preconditions for subsequent stages of transformation.

- **To Clarify Ecosystem Roles and Enable Coordinated Action:**

Finally, the research aims to move from abstract calls for collaboration to a clear delineation of the specific roles, responsibilities, and required actions for key stakeholders, including governments, financial institutions, technology providers, and SMEs themselves. The objective is to provide a clear framework for coordinated, multi-stakeholder action that aligns with the principles of inclusive and sustainable development.

In essence, the objective of this foresight research brief is to provide a comprehensive, evidence-based, and logically structured framework that empowers stakeholders to navigate the uncertainties of digital transformation and make strategic decisions today that will collectively shape a more inclusive and resilient digital future for SMEs.

3. SENSING THE ICT-EMPOWERMENT LANDSCAPE FOR SMES

This chapter provides a comprehensive environmental scan using the STEEPLE framework to identify the key dynamics, opportunities, and challenges shaping the digital transformation of Small and Medium-sized Enterprises (SMEs) through Information and Communication Technologies (ICT). It examines the social, technological, economic, environmental, political, legal, and ethical factors that define the current context and influence the effectiveness of ICT-empowerment strategies.

▶ 3.1. Social Dynamics: Evolving Workforce and Market Expectations

SOCIAL dynamics are redefining the SMEs operating environment through a clash of transformative drivers and structural barriers. This new social landscape is characterized by the rise of new economic actors, persistent inequalities, and evolving market paradigms.

Emerging actors are becoming powerful catalysts for digital adoption. Youth-led and women-led SMEs are pioneering digital tool use, spurred by government programs that raise awareness of online opportunities. This momentum is fueled by post-pandemic shifts to virtual networking and hybrid work models, which are reshaping collaboration. Additionally, youth bulges in developing economies and the expanding gig economy offer SMEs new sources of entrepreneurial talent and flexible labor.

However, these drivers are tempered by profound structural constraints. These include:

- **A critical digital talent gap stemming from global disparities in education and digital literacy;**
- **Compounding pressures from an aging workforce in developed economies and acute skill shortages in developing regions;**
- **A pervasive digital divide across urban-rural, gender, and ethnic lines that risks excluding vulnerable groups.**

Concurrently, new market and workplace expectations are compelling SMEs to adapt. SMEs' digital transformation goals reflect these pressures head-on: 47% prioritize increasing domestic sales and 41% aim to broaden their customer base, aligning with new consumption patterns like

e-commerce. Operational efficiency is another key driver, with 40% targeting automation—a goal for 48% of more digitally advanced firms (ICSB & OECD, 2024). These priorities underscore how Gen Z's demand for flexibility and growing sustainability pressures are reshaping operations. Consequently, SMEs face a pressing imperative to innovate their production and operational models.

▶ 3.2. Technological Dynamics: Lowering Barriers and Raising Stakes

TECHNOLOGICAL advancements are fundamentally reshaping the competitive landscape for SMEs, creating a dual reality of unprecedented opportunities alongside complex new challenges. The convergence of cloud-native platforms, artificial intelligence (AI), and advanced connectivity is dramatically lowering barriers to entry and scaling, while simultaneously raising the stakes by exposing SMEs to heightened risks and demanding new capabilities for navigating the digital economy.

A suite of innovations is actively dismantling traditional cost and expertise barriers. The widespread availability of cloud-native and low-code technologies revolutionizes how SMEs build and customize critical systems, significantly reducing development costs and enabling rapid deployment of tailored solutions. Coupled with declining IoT hardware costs, SMEs can now affordably deploy connected devices to optimize operations and gather valuable data. The penetration of AI serves as a powerful force multiplier, providing sophisticated analytics capabilities once reserved for large corporations and enabling rapid creation of lightweight, diverse applications at reduced costs. Technologies like 5G/6G and edge computing provide the reliable, high-bandwidth foundation required for data-intensive applications, while also enabling viable remote work and operational flexibility. New avenues for innovation continue emerging through open-source solutions and immersive technologies like AR/VR.

Despite these opportunities, significant hurdles persist. Many SMEs suffer from weak data governance capabilities and operate with basic, siloed applications, preventing deep operational integration and creating limiting Data Silos. Technical interoperability barriers and fragmented industry protocols hinder the creation of seamless digital ecosystems, while growing cybersecurity threats target SMEs despite emerging affordable security solutions. Additionally, existing generic digital solutions often fail to meet specific SMEs needs, and fully customized alternatives remain prohibitively costly, creating a concerning over-reliance on global platforms that raises questions about long-term resilience and data sovereignty.

In conclusion, strategic investments in foundational infrastructure and targeted support for building digital capabilities will determine which SMEs can fully harness these transformative technological opportunities while overcoming persistent challenges related to data integration, security, and system interoperability.

Box 1: F5.5G All-Optical Network Empowers Shenshan Medical Center

CT Empowers Healthcare-Huawei F5.5G 10 Gbps FTTO Solution Enables High-Quality Development of Shenshan Medical Center

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Key Challenge: Shenshan Medical Center required ultra-reliable, high-bandwidth network connectivity to support bandwidth-intensive and latency-sensitive applications like AI-driven diagnostics and real-time collaboration, amidst complex clinical environments.

ICT Solution: Deployment of an F5.5G 10Gbps Fiber-to-the-Office (FTTO) solution, integrating multiple isolated networks into one simplified, all-optical architecture with passive components and high redundancy.

Outcomes Breakdown: Achieved 99.999% network reliability, reduced energy consumption by 30%, increased network O&M efficiency by 60%, and enabled seamless high-definition image transmission, directly supporting smart hospital transformation.

Reference Value: This case exemplifies how next-generation F5.5G connectivity overcomes key digitalization barriers while enabling advanced applications like AI diagnostics. It demonstrates the critical role of high-performance infrastructure in achieving sustainable, resilient digital transformation for SMEs in high-stakes sectors like healthcare.

▶ 3.3. Economic Dynamics:
Efficiency Gains Amid Financial Constraints

ECONOMIC factors create a powerful, yet complex, impetus for change. ICT tools offer clear pathways to lean production, improved resource efficiency, and data-driven decision-making, which have become core to competitiveness. However, SMEs face significant constraints, including low profit margins, cost sensitivity, and widespread difficulties in accessing affordable financing—a challenge underscored by a $5.7 trillion MSME finance gap in emerging markets and developing economies (World Bank & IFC, 2025). The severity of this financing challenge is starkly illustrated by data from developing economies, which reveals that on average, 18% of SMEs are fully financially constrained, with significant regional disparities—ranging from around 14% in Europe and Central Asia to over 25% in South Asia and Sub-Saharan Africa (see Figure 1).

Figure 1: Number of Financially-Constrained MSMEs by Region
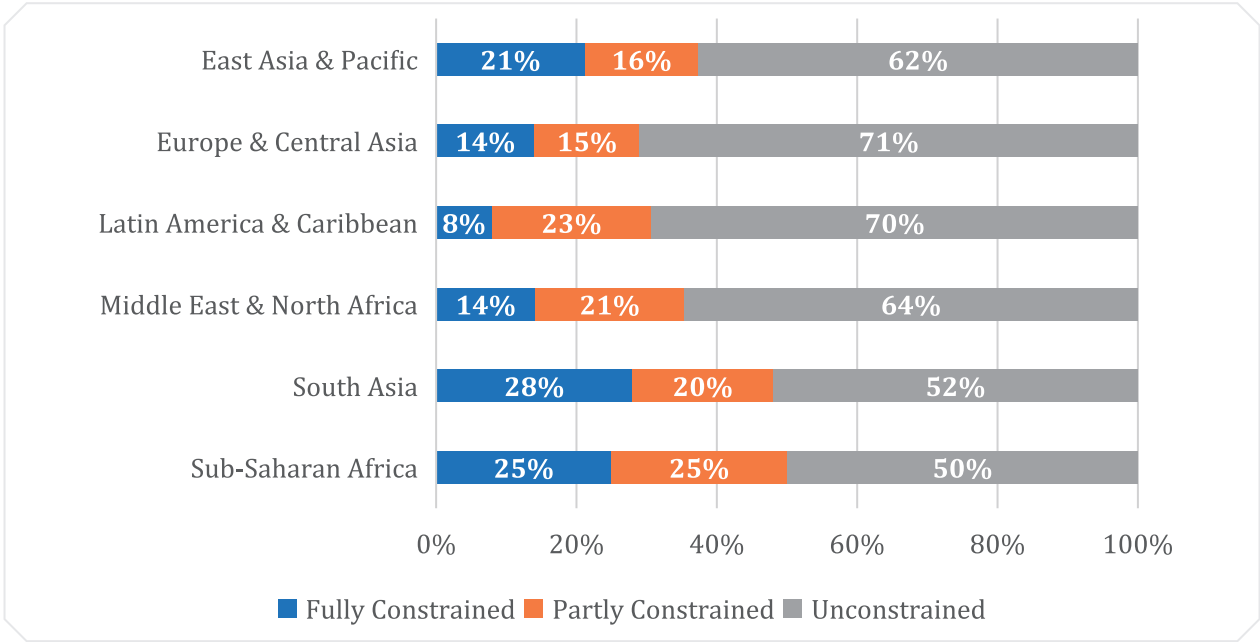
Sources: World Bank & IFC, 2025

These barriers make sustained investment in deep digital transformation particularly difficult, often leading to superficial digitalization. Moreover, a digital divide in capital flows exacerbates the situation, as investors tend to favor high-growth digital startups, leaving traditional SMEs struggling to secure transformation finance despite expanding cross-border trade opportunities. Faced with constraints of this magnitude, the development of innovative financing models based on data assets, coupled with the SaaS subscription model, becomes not just beneficial but essential to ease cash flow pressures and open new funding avenues for the SMEs most in need.

▶ 3.4. Environmental Dynamics: The Green and Digital Convergence

ENVIRONMENTAL considerations are increasingly intertwined with digital transformation, creating both pressures and opportunities for SMEs. SMEs account for approximately 90% of businesses globally and contribute around 40% of global greenhouse gas emissions (ADBI, 2025), highlighting their critical role in environmental dynamics. Carbon neutrality regulations and stringent environmental standards, such as those under the European Green Deal (European Commission, 2024), are imposing significant cost pressures and market access requirements. Concurrently, growing green consumer awareness and ESG-driven sourcing requirements are pushing SMEs to adopt eco-friendly practices. Climate-conscious consumers are becoming more influential, and firms demonstrating environmental responsibility can attract loyal customer bases, thereby enhancing brand value and market recognition.

Moreover, 70% of SMEs reported direct consequences from climate change, including supply chain disruptions and asset damage (ADBI, 2025), which compels them to adopt digital tools for full lifecycle traceability, energy conservation, and compliance demonstration. Digital transformation serves as a key enabler for SMEs to respond to these pressures. It helps businesses design energy-efficient products, optimize logistics against climate disruptions, and integrate circular models such as repair and recycling. For example, the ESCAP report (ESCAP, 2024) highlights initiatives like Singapore's Gprnt digital platform, which automates ESG data collection and reporting, reducing the manual burden on SMEs. Digital platforms further contribute by reducing physical travel and paper use, thereby lowering carbon emissions.

However, the rising energy demands of cloud and AI computing highlight the need for green ICT solutions and sustainable business models, as noted in the European Covenant (European Commission, 2024), which points to infrastructure limitations as a barrier. Notably, access to climate-aligned funding—such as green bonds and ESG-linked loans—is increasingly tied to robust digital monitoring and reporting capabilities. The ADBI brief (ADBI, 2025) and ESCAP report (ESCAP, 2024) provide examples like Korea's green credit guarantees and Thailand's Bio-Circular-Green (BCG) loans, which require digital compliance for eligibility. Thus, ICT adoption not only addresses regulatory and market pressures but also unlocks financial pathways for SMEs to participate actively in the circular economy, as demonstrated by capacity-building programs in Vietnam and Malaysia (ESCAP, 2024) that combine digital tools with green finance access.

Box 2: Satellite IoT for Environmental and Heavy Machinery Monitoring

Environmental and Heavy Machine Monitoring Based on Satellite Internet of Things

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Key Challenge: Monitoring environmental equipment and heavy machinery in remote areas with no terrestrial network coverage was impossible, leading to operational inefficiencies and unchecked environmental risks.

ICT Solution: Deployment of satellite Internet of Things (IoT) terminals on equipment to enable real-time data transmission via low-orbit satellites, ensuring continuous monitoring and control anywhere.

Outcomes Breakdown: Achieved full-time, global data interaction, enabled predictive maintenance to reduce downtime, cut operational costs by 15%, and ensured zero crude oil leaks, enhancing environmental safety.

Reference Value: This case highlights how satellite IoT can bridge the connectivity divide, providing a critical solution for managing assets and ensuring sustainability in infrastructure-poor regions, thus unlocking new possibilities for industrial monitoring.

▶ 3.5. Policy Dynamics: Strengthening Support for SMEs Digitalization

POLICY efforts to support SMEs digitalization are intensifying globally. A growing number of countries are implementing dedicated national strategies, financial subsidies, and capacity-building programs specifically designed to accelerate digital adoption among SMEs. Concurrently, regional economic integration agreements are actively improving the policy environment for digital trade, facilitating broader cross-sector collaboration that provides SMEs with greater access to technology and markets.

International collaborative frameworks, such as the Digital Economy Partnership Agreement (DEPA), offer innovative pathways for aligning standards and fostering cross-border digital cooperation. These plurilateral initiatives help create a more predictable and interconnected digital trading space for SMEs.

A critical enabler in this process is the strategic use of Information and Communication Technologies (ICT). Digital platforms, cloud services, and modular solutions are proving instrumental in amplifying the reach and impact of policy support. By significantly lowering access thresholds and operational costs, these technologies help ensure that a wider range of SMEs can practically benefit from available policy measures.

In summary, the ongoing strengthening of policy support, combined with strategic international cooperation and the targeted integration of ICT tools, is progressively enhancing the effectiveness and inclusivity of digital transformation efforts for SMEs worldwide.

Box 3: Huadu District's New-type Industrialization Digital Service Platform

The Practice of Huadu District's New-type Industrialization Digital Service Platform in Empowering SMEs' Digital Transformation

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Key Challenge: SMEs in Huadu District faced significant financial and technical barriers to digital transformation. High upfront costs, complex solutions, and a lack of technical expertise resulted in a low adoption rate of digital tools, hindering their competitiveness and efficiency.

ICT Solution: The solution centered on a collaborative industrialization digital service platform, developed by the Huadu District Government with partners like Huawei. It employed a cloud-based AI engine and a modular "1+3+N" architecture to offer affordable, on-demand digital services. A critical enabler was a tiered subsidy model—free first year, 50% off the second, and 30% off the third—which reduced upfront costs and encouraged SMEs participation by allowing them to select lightweight, combinable modules (e.g., for supply chain or marketing) without full-system commitments.

Outcomes Breakdown: The platform achieved scalable impact, supporting over 300 SMEs by September 2025. It drove a 25% increase in production efficiency, a 30% reduction in inventory turnover time, and a 60% cut in R&D cycles, while lowering transformation costs by over 60% through its modular approach.

Reference Value: This case exemplifies a highly replicable "Government Guides, Market Operates" model for policy implementation. It demonstrates how public-sector platforms can effectively de-risk digital transformation for SMEs through financial incentives, standardized yet modular technical solutions, and ecosystem collaboration. This approach directly addresses common implementation gaps in policy support, providing a blueprint for other regions globally to accelerate inclusive industrial digitalization and bridge the digital divide for SMEs.

▶ 3.6. Legal Dynamics: Regulatory Frameworks and Compliance Challenges

LEGAL frameworks present both foundational support and formidable challenges for SMEs undergoing digital transformation through their rapid evolution. While regulations governing e-commerce, digital payments, and data protection establish essential ground rules for digital trade, their complexity often overwhelms SMEs' limited resources. Figure 2 demonstrates significant disparities in regulatory maturity across regions, highlighting the uneven compliance landscape that SMEs must navigate.

Figure 2: Readiness of ICT legal and regulatory frameworks by region, 2024
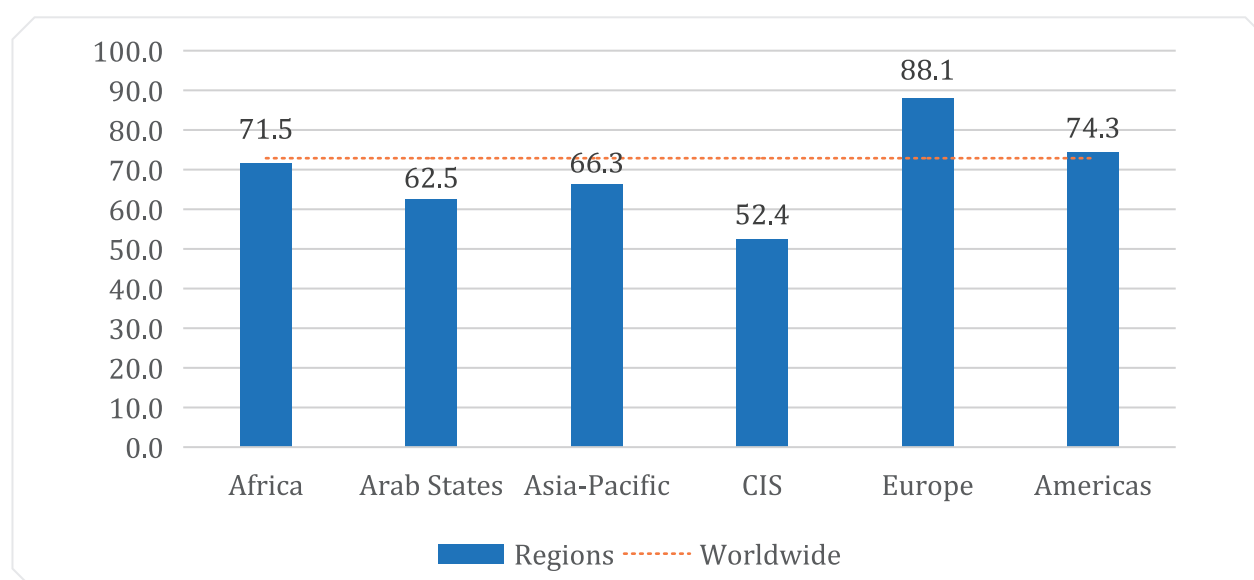
Source: ITU. Compiled by CAICT

ICT technologies themselves offer powerful solutions to these legal challenges. Cloud-based compliance platforms can automate GDPR and CCPA requirements, while blockchain solutions enable transparent cross-border data management. AI-powered tools help SMEs monitor regulatory changes and assess intellectual property risks in cloud services adoption. Yet, these technological solutions require cybersecurity capacities that many SMEs lack, creating a dual challenge of adopting both new technologies and new compliance measures simultaneously.

The most significant legal barrier remains SMEs' limited influence over industry standards and regulation development. While large enterprises participate in standard-setting processes, SMEs often face finished regulatory frameworks that prioritize larger actors' interests. This imbalance is particularly evident in emerging areas like AI governance and digital product liability, where compliance costs disproportionately impact smaller businesses.

Ultimately, the relationship between legal frameworks and ICT empowerment is bidirectional: evolving regulations drive SMEs digitalization needs, while ICT tools enable compliance. Strategic adoption of regulatory technology (RegTech) can transform legal challenges into competitive advantages, allowing agile SMEs to leverage compliance as a trust-building mechanism with customers and partners. This synergy represents a critical frontier in the digital transformation journey, where technology adoption and regulatory adaptation must advance together.

▶ 3.7. Ethical Dynamics: Ensuring Responsible and Inclusive Growth

ETHICAL considerations are becoming critical determinants of how effectively SMEs can harness ICT for digital transformation. The concentration of core AI models and data resources in the hands of global tech giants creates fundamental barriers, limiting SMEs access to essential digital production factors and potentially locking them out of next-generation innovation cycles. For instance, in Asia, only 30% of SMEs have access to advanced AI tools due to resource centralization (ADB, 2024). This technological disparity exacerbates existing inequalities, disproportionately affecting vulnerable groups such as women-led businesses, older entrepreneurs, and remote SMEs who face heightened risks of digital exclusion. Studies show that women-led SMEs are 40% less likely to adopt digital technologies compared to male-led counterparts, further widening the gap.

Algorithmic transparency and fairness have emerged as pivotal concerns within this landscape. SMEs must navigate risks ranging from algorithmic discrimination in financing applications—where AI systems may unfairly deny loans based on biased data—to ethical dilemmas in AI deployment, while simultaneously guarding against technology misuse such as generative AI-enabled fraud. Furthermore, the societal implications of digital transformation—including AI-driven job displacement and environmental sustainability—demand proactive management through vocational retraining and green technology adoption. Advocating for a people-centered framework and incorporating ethical principles into digital strategies to ensure that small and medium-sized enterprises benefit from inclusive design and fair access (U4SSC, 2025).
The path forward requires building ethical considerations directly into SMEs digital transformation strategies. This includes implementing transparent AI systems, establishing clear boundaries for technology use, and promoting inclusive design principles. By embedding ethical frameworks into their digital evolution, SMEs can not only mitigate risks but also position themselves as trusted participants in the digital economy, turning responsible practices into competitive advantages that support sustainable and equitable growth.

▶ Reflection:
An Interconnected Landscape of Drivers and Frictions

The STEEPLE analysis reveals a context defined by powerful technological enablers and strong social and economic drivers, which are simultaneously countered by significant structural frictions. These seemingly disparate challenges are not isolated issues. Our analysis indicates they are interconnected and mutually reinforcing, forming the core systemic bottleneck to SMEs digital transformation. This leads us to propose the "Triple Divide" as a diagnostic framework to crystallize the essence of the problem:

• **Technical Divide: Emerging technological tools (e.g., AI, big data analytics) remain costly and complex for SMEs to adopt.**

• **Funding Divide: Traditional financial institutions' credit models fail to effectively assess SMEs' digital potential and data assets, leading to persistent challenges in access to affordable capital.**

• **Skills Divide: SMEs generally lack digital talent and systematic upskilling pathways, resulting in an inability to effectively use tools and translate technology into practical productivity.**

Crucially, the Triple Divide functions as a dynamic system. A deficit in one area exacerbates challenges in others, creating a self-reinforcing cycle of exclusion.
The following chapter provides an in-depth analysis of the key drivers of change shaping this landscape, thereby setting the stage for developing targeted and effective interventions.

4. MAPPING THE KEY DRIVERS OF CHANGE FOR ICT-EMPOWERED SMES

This chapter analyzes the phase of refining the drivers of change. Building on insights from the scanning phase, we identify and assess key drivers based on their potential impact on the future and the degree of uncertainty surrounding their realization. This assessment utilized the Delphi method, engaging over ten experts proficient in both ICT development and the dynamics of SMEs. Through three rounds of structured feedback, these experts collectively shaped the final evaluation. Finally, the outcome is a refined set of drivers that serves as a critical input for the scenario development in the subsequent chapter.

▶ 4.1. Critical Forces Shaping the Landscape

Through a STEEPLE analysis, we conducted a brainstorming session on the external factors influencing ICT-empowered SMEs. Subsequently, we employed the Affinity Grouping method to categorize these factors into ten key drivers, detailed in Table 1.

A preliminary assessment reveals that the majority of these drivers present a combination of high potential impact and high uncertainty, highlighting the complex and volatile environment in which SMEs should operate. They encompass a range of external factors, including technological adoption hurdles, evolving regulatory landscapes, and transformative labor markets.

Table 1: Key Drivers for ICT-Empowered SMEs: Impact and Uncertainty Assessment

Drivers	Impact	Uncertainty
Global Systemic Risks and Resilience Requirements	High	High
Market and Consumer Behavior Shifts	High	High
Labor and Skills Transformation	High	Medium
Policy Support and Regulatory Frameworks	High	High
Compliance, Security, and Legal Risks	High	High
Technology Adoption and Cost Reduction	High	High
Technology Implementation and System Integration Challenges	High	Medium
Funding and Financing Model Innovations	High	High
Sustainability Integration	Medium	High
Ethical and Social Inclusivity Challenges	Medium	High

Figure 3 maps these complex interdependencies, revealing a system of drivers where changes in one area can ripple through others. This network perspective is crucial for understanding the dynamic environment SMEs navigate.

Figure 3: The Interdependencies Between the Drivers
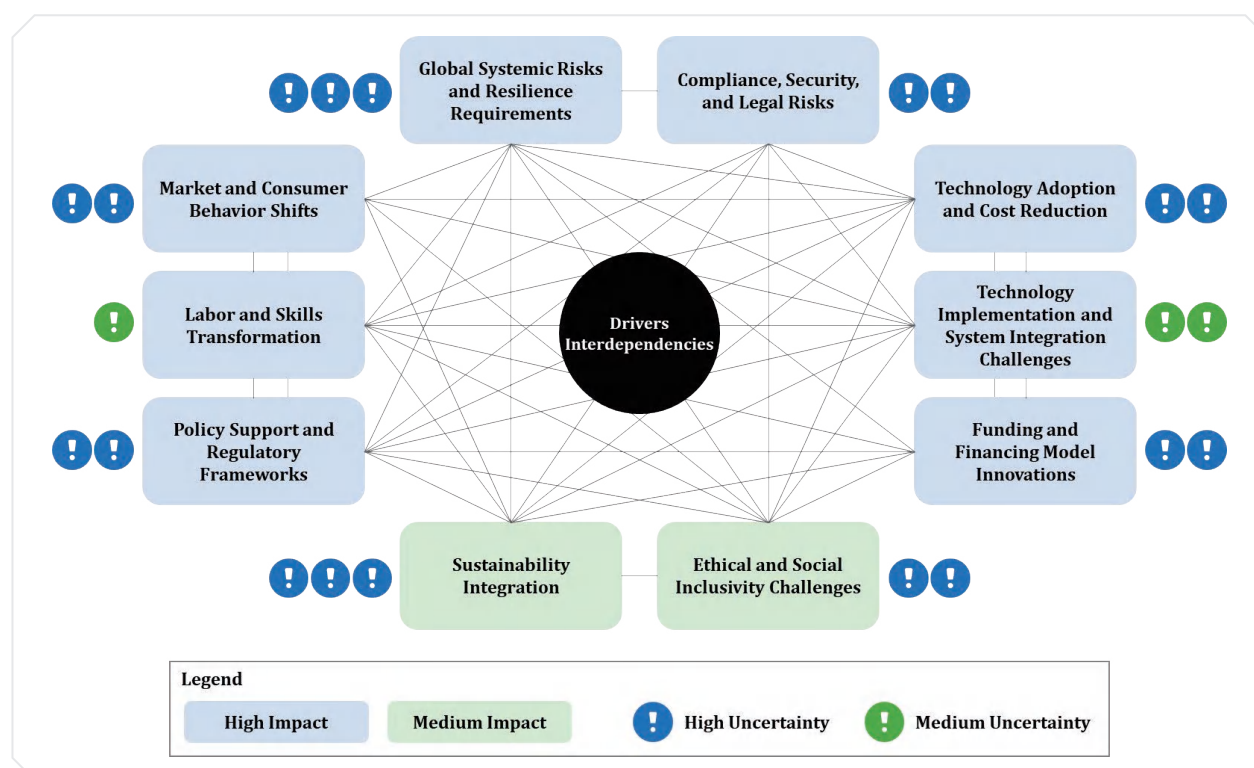
The complex interdependencies among these key drivers, mapped in Figure 3, create a dynamic system. To illustrate this, consider two causal pathways:

- **Policy Driving Technology, Technology Reshaping the Market**

Robust "Policy Support and Regulatory Frameworks" (such as special subsidies for SMEs adopting emerging technologies) directly stimulate demand for specific green or safety technologies. This significantly accelerates the process of "Technology Adoption and Cost Reduction". As technologies mature and costs decline, SMEs are compelled or incentivized to adopt these new technologies. This, in turn, profoundly transforms "Market and Consumer Behavior Shifts", catalyzing new green consumer markets or restructuring supply chain relationships. These changes create opportunities for SMEs that can adapt quickly, while simultaneously increasing survival pressures for those slower to respond.

- **Risks Constrain Funding, Funding Impacts Transformation**

Escalating "Global Systemic Risks and Resilience Requirements" (e.g., supply chain disruptions or geopolitical conflicts) can trigger macroeconomic fluctuations, leading to a decline in investor risk appetite. This increases the difficulty for SMEs to secure "Funding and Financing Model Innovations" (such as a contraction in venture capital). The narrowing of financing channels directly exacerbates the resource constraints SMEs face when encountering "Technology Implementation and System Integration Challenges", potentially forcing them to delay or scale down their digital transformation plans, thereby putting them at a greater disadvantage in the long-term competitive landscape.

This complex interplay of drivers creates a volatile environment for SMEs. Navigating this volatility makes digital transformation not an option but an imperative. Success, however, hinges critically on leveraging new-generation ICT. Effective empowerment through ICT unlocks the integrated value of production data, leads to the pervasive digital transformation of vertical industry processes, and ultimately propels efficient resource allocation and business model upgrades.

To navigate this landscape, it is essential to understand the key drivers at play. The following section delves into each of these drivers to detail their specific influences on SMEs' digital transformation journey.

▶ 4.2. Unpacking the Drivers of Change

▶ Global Systemic Risks and Resilience Requirements

This driver encompasses threats that transcend individual enterprises or industries, characterized by their global interconnectedness. These threats can disrupt economic activity, supply chains, technological flows, and political stability, thereby constituting fundamental challenges for all market participants, especially SMEs with a lower capacity to withstand risks. The evolving nature of these challenges is clearly captured in longitudinal risk survey data (see Figure 4).

Figure 4: Leading Risks for Small Enterprise Companies Worldwide (2018-2025)
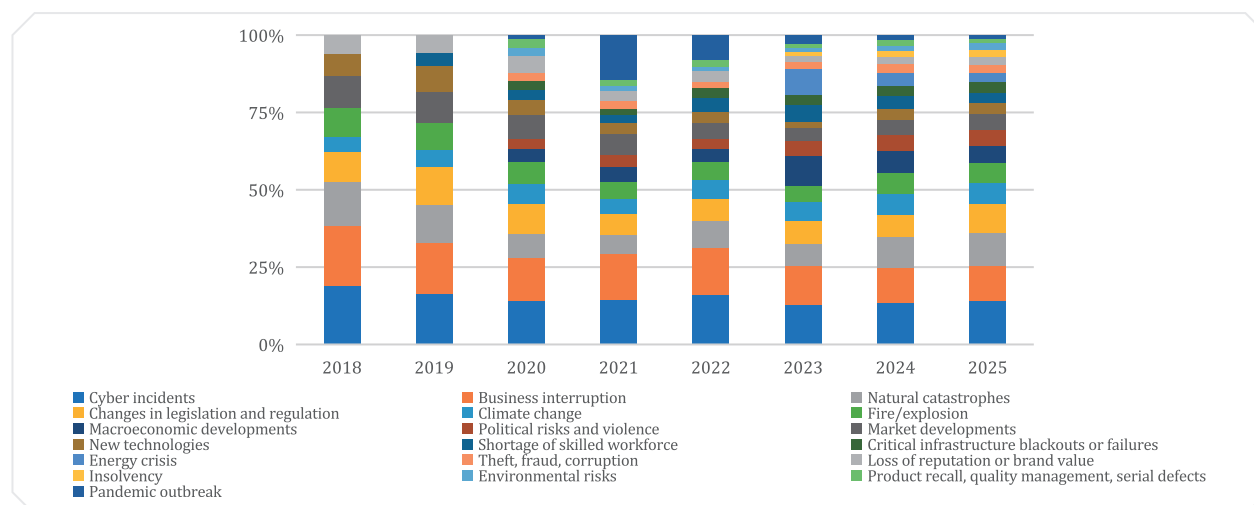
Source: Allianz, 2025. Data sourced from Statista.

As Figure 4 illustrated, cyber incidents have consistently remained the paramount concern, underscoring the critical vulnerability of digital infrastructure. Meanwhile, macroeconomic developments and business interruption have emerged as persistently significant threats, reflecting the increased volatility of the global operating environment.

These challenges are manifested in several concrete ways:

• **Cyber incidents pose critical threats to SMEs digital infrastructure and data security;**
• **Trade protectionist policies in some countries/regions lead to a lack of continuity in digitalization support for SMEs;**
• **Geopolitical conflicts introduce external technology risks and supply chain uncertainties;**
• **Extreme climate events impact global logistics networks.**

Collectively, these factors impose urgent resilience requirements on SMEs, particularly concerning the digitalization of their supply chain management and business continuity planning.

This driver closely interacts with several other factors in the system. For instance, it directly exacerbates the costs and complexity of Technological Implementation and System

IntegrationChallenges, influences the direction of Policy Support and Regulatory Frameworks, and shapes the expectations for stability and sustainability within Market and Consumer Behavior. Consequently, for SMEs, digitalization is no longer merely a tool for efficiency gains but a core strategic asset for building business resilience. When formulating digital transformation plans, it is imperative to treat resilience and risk resistance as core evaluation dimensions, prioritizing the adoption of flexible supply chain solutions, data backup and recovery technologies, and compliant designs that meet multiple regulatory requirements. This approach is crucial for maintaining business continuity and adaptability in a highly uncertain global environment.

▶ Market and Consumer Behavior Shifts

This driver refers to fundamental changes in market demand, consumption patterns, and customer expectations, collectively driven by technological innovation, generational shifts, and evolving values. It necessitates that enterprises, particularly SMEs, transition from a product-centric to a customer-centric approach and develop agile responsiveness. Specific manifestations include:

- **Heightened expectations among the younger generation for work flexibility, meaningful engagement, and seamless technological experiences;**
- **Rising importance of data-driven decision-making as a core competency;**
- **Significant increase in demand for personalized consumption;**
- **Emergence of green consumption consciousness that creates brand premium opportunities;**
- **Growing need for remote work solutions.**

Together, these elements constitute a complex, diverse, and rapidly evolving market environment. This driver exerts a dynamic interplay with other factors within the system. It serves as both an outcome and a primary application scenario for Technology Adoption and Cost Reduction, while simultaneously shaping Labor and Skills Transformation (e.g., by driving demand for remote work capabilities). Conversely, it is itself shaped and constrained by Global Systemic Risks (e.g., supply chain disruptions impacting product delivery) and Policy and Regulatory Frameworks (e.g., data privacy laws).

Consequently, for SMEs, the ability to understand and rapidly respond to market and consumer behavior shifts has evolved from a competitive advantage into an essential capability for survival. The central imperative, therefore, is to anchor their digital transformation unwaveringly around enhancing customer insight and market agility. This entails actively leveraging data-driven decision-making, investing in flexible production capabilities and personalized customization, and proactively integrating Environmental, Social, and Governance (ESG) factors into their brand narrative. By doing so, SMEs can achieve precise positioning within the complex market landscape and co-create sustainable competitive advantages alongside consumers and value chain partners.

Box 4: AI-Powered Marketing for Omnichannel Operations

AI-powered marketing technology empowers enterprises with omnichannel operations

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Key Challenge: A cosmetic brand struggled with fuzzy user profiling, decision-making blind spots, and fragmented membership assets across online and offline channels.

ICT Solution: An AI Marketing Cloud that integrated omnichannel data to build 360° user profiles, enabling hyper-personalized campaigns and data-driven distributor management.

Outcomes Breakdown: Increased dealer-side communication efficiency by over 50%, boosted customer repurchase rate by 30%, and shortened high-intent customer conversion cycles to within 3 days.

Reference Value: This case shows how AI-powered insights enable SMEs to transition from broad-reach marketing to precision targeting and experience-driven growth, meeting evolving consumer demands.

▶ Labor and Skills Transformation

This driver refers to the fundamental reshaping of the supply and demand structure of the labor market, the nature of work, and skill requirements, under the dual pressures of technological change and demographic shifts. It compels both businesses and workers to engage in continuous adaptation and learning; failure to do so will lead to the challenges of skill obsolescence and talent shortages. Specific manifestations include:

- **Uneven global distribution of education levels and digital literacy, which intensifies the competition for talent;**
- **Significant digital skill gaps, especially for developing economies;**
- **Simultaneous replacement of certain traditional jobs by artificial intelligence alongside the creation of new business models.**

Collectively, these changes result in a pronounced digital talent gap, thereby directly constraining the digital transformation progress of SMEs and raising the barrier to entry due to the high costs associated with training.

This driver interacts closely with other factors within the system. It is directly propelled by Technology Adoption and Cost Reduction (e.g., AI applications creating new roles) and significantly influences an SME's ability to respond to Market and Consumer Behavior Shifts (e.g., the inability to reach new markets without digital marketing talent). Conversely, the success of its transformation is dependent on support from Policy and Regulatory Frameworks (e.g., vocational training subsidies).

Therefore, for SMEs, it is imperative to position a Talent Strategy at the core of digital transformation, rather than treating it as a supporting function to be considered afterward. The key insight is that SMEs could adopt a dual-track strategy:

- **On the one hand, actively leverage digital learning platforms and tools to invest in the upskilling and reskilling of existing employees, thereby building an internal talent pipeline;**
- **On the other hand, proactively explore flexible employment models and collaborate with external networks of specialized professionals to compensate for short-term capability gaps.**

Viewing employees as Human Capital requiring continuous investment, rather than merely as a cost, is fundamental to building long-term competitiveness in the age of skills.

Box 5: AI for Cultivation of Industrial Technical Professionals

BIFNC's AI Empowers the Cultivation of Industrial Technical Professionals

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Key Challenge: Industrial skills education was hampered by homogenized courses that failed to meet diverse skill-level needs, creating a gap between training and actual job requirements.

ICT Solution: A large AI model-based platform featuring an AI Agent that provides personalized learning paths, intelligent tutoring, and real-time skills assessment.

Outcomes Breakdown: Reduced the proportion of manual responses from 70% to 30%, cutting Q&A costs by 60-80%, and increased course completion and renewal rates by 5-10%.

Reference Value: This solution directly addresses Labor and Skills Transformation by demonstrating how AI can democratize access to personalized, scalable, and efficient vocational training, which is critical for bridging the digital talent gap that constrains SMEs transformation.

▶ Compliance, Security, and Legal Risks

This driver refers to a series of operational challenges and potential liabilities faced by SMEs during their digital transformation, stemming from the need to comply with increasingly complex and dynamic regulations, address escalating cyber threats, and avoid new types of legal disputes. Specific manifestations include:

- **Growing intricacy of regulatory requirements, makes compliance itself a specialized and costly challenge;**
- **Widespread shortage of cybersecurity skills and funds, makes it difficult for SMEs to implement protective measures that meet legal standards, exposing them to ethical and legal risks from data breaches and misuse;**
- **Lack of transparency and explainability in AI black box algorithms, which may lead to discriminatory outcomes and regulatory accountability;**
- **Risk of generative AI being misused for fraudulent marketing or disinformation is becoming more prominent;**
- **Simultaneously, during processes involving cross-border data flows, cloud service adoption, and platform integration, SMEs face complex international legal challenges such as intellectual property disputes and patent licensing, often with extremely high coping cost.**

Collectively, these risks form unavoidable red lines on the path of digital transformation for SMEs. This driver interacts strongly with almost all other factors within the system. It is directly shaped by the Policy and Regulatory Framework and profoundly affects the feasibility of Technology Adoption and Cost Reduction (where high compliance costs can offset technological benefits). It is also tightly interwoven with Global Systemic Risks (such as data localization requirements driven by geopolitics) and Market and Consumer Behavior Shifts (such as consumer expectations regarding data privacy and ESG).

Therefore, for SMEs, it is imperative to integrate security and compliance consideration into the blueprint and processes of digital transformation from the outset. rather than resorting to post-hoc remedies. The key to this approach is treating compliance, data security, and legal risk assessment as core dimensions in technology selection and architectural design during the initial planning, rather than resorting to post-hoc remedies. Prioritizing technology platforms and services with built-in compliance and security features, along with actively seeking external professional legal and compliance consulting, can transform uncertain legal risks into manageable operational costs. This approach enables SMEs to find a sustainable balance between innovation and compliance, ensuring a steady and far-reaching digital transformation.

▶ Technology Adoption and Cost Reduction

This driver refers to the increasing maturity, proliferation, and commoditization of new-generation Information and Communication Technologies (ICT), such as AI, cloud-native, SaaS, 5G/6G, and IoT, which have led to a significant reduction in their acquisition, deployment, and application costs. This trend enables SMEs to adopt digital tools that were once expensive or complex at a substantially lower threshold. It is characterized by:

- **Accelerated penetration of AI technology, which not only reduces application development costs, allowing SMEs to rapidly create small-scale, diverse applications, but also provides them with rapid access to intelligent analytics capabilities;**
- **Widespread adoption of cloud-native and low-code technologies, which dramatically lowers the technical barriers and development costs for SMEs to acquire and customize core systems like ERPs and MESs;**
- **SaaS subscription model, which effectively alleviates cash flow pressure;**
- **Declining costs of 5G/6G and IoT hardware provide a reliable connectivity foundation, while the development of green energy contributes to lowering overall computing costs.**

Collectively, these factors create unprecedentedly favorable conditions for SMEs to widely adopt ICT, achieve lean production, enhance resource utilization efficiency, and even design and produce more environmentally friendly products for differentiated competition.

This driver acts as one of the most central enablers within the system, engaging in profound two-way interactions with other factors. It directly empowers the capacity to respond to Market and Consumer Behavior Shifts, serves as a key tool for addressing challenges associated with Labor and Skills Transformation, and its development pace is influenced by the Policy and Regulatory Framework. Simultaneously, its security and compliance dimensions constitute significant aspects of Compliance, Security, and Legal Risks.

The key for SMEs, therefore, lies in adopting a judicious technology adoption strategy rather than indiscriminately pursuing the latest technology. A central insight is that SMEs would benefit from closely monitoring the trend of declining technology costs and prioritizing solutions that offer subscription models, ease of integration, and potential for rapid value generation. When formulating a digital transformation roadmap, a prudent evaluation of the technology's total cost of ownership against anticipated returns is crucial. This allows SMEs to leverage the cost advantages afforded by technological proliferation, converting them into agility and innovation benefits, while remaining mindful of risks such as vendor lock-in and over-dependence.

Box 6: Lightweight ICT Service Package for Agricultural SMEs

Joyvio Group's "Lightweight ICT Service Package" Empowers the Whole-Process Digital Transformation of SMEs in Agriculture

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Key Challenge: Agricultural SMEs relied on experiential planting with unrecorded field data, leading to inefficient coordination across harvesting, processing, and sales.

ICT Solution: A "Data Foundation + Modular Applications" architecture using cloud servers and selectable ICT modules (e.g., production monitoring, supply chain collaboration) lowered the technical and cost barriers to entry.

Outcomes Breakdown: Achieved an average 18% increase in production efficiency, a 25% improvement in supply chain responsiveness, and successfully replicated the solution across multiple agricultural sectors.

Reference Value: This case exemplifies the core theme of Technology Adoption and Cost Reduction by demonstrating how modular, lightweight solutions can dramatically lower the threshold for SMEs to adopt digital tools and achieve significant returns.

▶ **Technology Implementation and System Integration Challenges**

This driver encompasses the specific technical obstacles and operational bottlenecks SMEs encounter when deploying diverse digital technologies and attempting to integrate them into a cohesive, data-fluent operational system. It addresses the core dilemma of usability and interoperability, moving beyond mere technology availability. Critically, the nature of these challenges evolves significantly as an enterprise progresses along its digital maturity journey, as illustrated by the varying focus of transformation demands across different development stages (see Figure 5).

Figure 5: Transformation Demands of SMEs at Different Development Stages
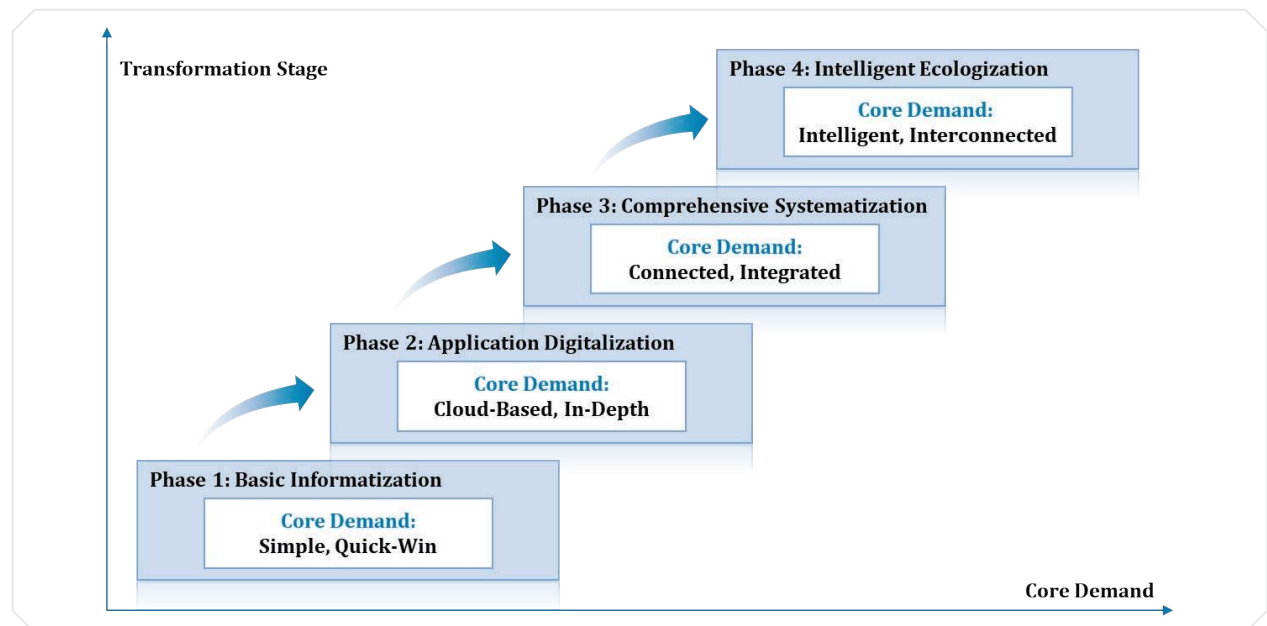
Source: CAICT, 2025

The progression shown in Figure 5 —from seeking "Simple, Quick-Win" solutions at the foundational level to demanding "Intelligent, Interconnected" ecosystems at the advanced stage—reveals a fundamental shift in integration challenges. Initial manifestations include the high cost of personalized digital solutions, as off-the-shelf offerings often fail to meet specific SMEs needs. As maturity increases, prevalent technical standards and interoperability barriers create data silos between systems from different vendors, hindering seamless data exchange. Widespread data security concerns regarding integration safety can delay progress at any stage, while an overall insufficient depth of digital application—often limited to isolated functions rather than end-to-end business process integration—and weak underlying data governance capabilities collectively form a chasm separating SMEs that merely possess digital tools from those that achieve true digital operation.

This driver is tightly coupled with other factors within the system. It represents the ultimate test for realizing the benefits promised by Technology Adoption and Cost Reduction. Its success directly determines an enterprise's capacity to effectively respond to Market and Consumer Behavior Shifts. It is a significant source of Compliance, Security, and Legal Risks (e.g., integration vulnerabilities as a primary security risk). And it is heavily influenced by constraints within the Policy and Regulatory Framework (e.g., cross-border data flow rules).

Consequently, for SMEs, adopting an integration-first approach and prioritizing data connectivity as core principles in technology selection and implementation is critical. A pivotal insight is that during initial digital planning, SMEs are advised to prioritize technologies characterized by open APIs, ease of integration, and adherence to mainstream standards to avoid vendor lock-in. Regarding implementation strategy, an iterative approach is often more effective than attempting a comprehensive, all-at-once system overhaul. Furthermore, early investment in building robust internal data governance capability, treating data as a core asset, constitutes a fundamental prerequisite for achieving effective system integration and unlocking data value.

▶ Funding and Financing Model Innovations

This driver pertains to the evolution of financial instruments and funding mechanisms tailored for SMEs' digital transformation, which move beyond traditional collateral-based credit. Its core objective is to address the twin challenges of funding accessibility and risk affordability that SMEs face in their digital transition. Specific manifestations include:

- **Limited resources and a heightened sensitivity to short-term financial performance make it difficult for SMEs to bear the long-term investment pressures of digital transformation;**
- **Hesitation regarding deep transformation projects requiring sustained investment, resulting in a prevalent adoption of superficial digitalization strategies to mitigate risk;**
- **Widespread difficulty in accessing affordable financing directly hinders the initiation and execution of SMEs digital transformation plans.**

Against this backdrop, innovative financing models based on data assets have emerged, aiming to assess a company's future digital earning potential rather than relying solely on historical financial statements, thereby providing SMEs with new and more suitable financial support.

This driver exhibits a strong two-way dependency with other factors in the system. It is a critical enabler for initiating Technology Adoption and Cost Reduction and Technology Implementation and System Integration (as these are unattainable without funding), while its own development relies on clarity within the Compliance, Security, and Legal Risks domain (e.g., the legal enforceability of data asset collateralization). Simultaneously, a successful digital transformation, by enhancing a firm's operational data and credit profile, can positively feedback into this driver, creating a virtuous cycle.

Therefore, it becomes imperative for SMEs to treat building digital credit as a strategic priority on par with improving operational efficiency. A key insight is that SMEs are advised to consciously accumulate, govern, and structure their core business data in daily operations, managing it as a future strategic asset. Furthermore, proactively exploring innovative financing models based on data assets, intellectual property, and supply chains, while actively engaging with financial institutions that understand the digital economy, can help SMEs translate their digital potential into tangible capital access. This approach offers a viable path to overcoming the resource bottlenecks that constrain transformation.
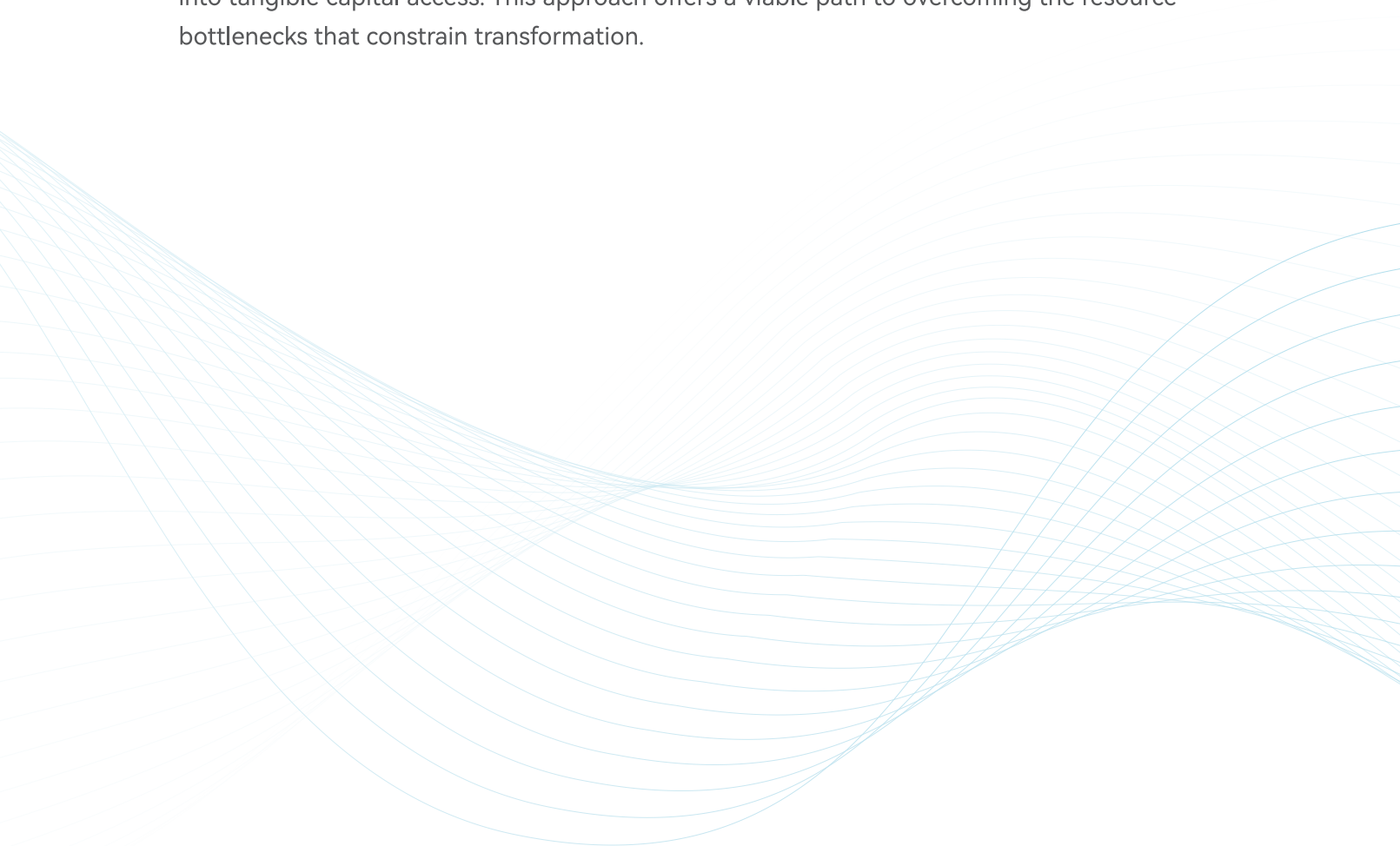
Box 7: Pakistan Startup Connect (PSC) Portal for Cross-Border Collaboration

Pakistan Startup Connect (PSC) Portal – Enabling SMEs Digital Transformation through Cross-Border Collaboration

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Key Challenge: Pakistani SMEs faced severe bottlenecks in accessing finance, fragmented business networks, and minimal global visibility, hindering their growth and innovation.

ICT Solution: An AI-powered digital matchmaking platform that connects startups and SMEs with investors, corporates, and mentors globally, facilitating virtual networking and deal-making.

Outcomes Breakdown: Digitally connected over 2,000 SMEs/startups to investors and international markets, mobilizing financing discussions and expanding market access without high transaction costs.

Reference Value: This initiative is a prime example of Funding and Financing Model Innovations, showcasing how digital platforms can create new, data-driven pathways for SMEs to access capital and strategic partnerships beyond traditional lending.

▶ **Policy Support and Regulatory Frameworks**

This driver encompasses the totality of laws, regulations, strategies, and fiscal measures enacted by various levels of government and international organizations, aimed either at directly supporting or indirectly influencing the digital transformation of SMEs through rule-setting. It constitutes the ground rules and foundational conditions that SMEs must operate within, capable of providing key impetus while also posing significant obstacles. Its manifestation is a complex duality:

• **On one hand, numerous countries have launched digital transformation support strategies for SMEs (including financial subsidies), and regional economic integration agreements create favorable policy environments, demonstrating proactive governmental support.**

• **On the other hand, significant challenges exist, including potentially reduced support for SMEs in some countries/regions due to poor government fiscal health, and uncertainty stemming from SMEs' sensitivity to tax burdens, where tax relief policies significantly impact profitability.**

More complex challenges arise from regulatory rules themselves, such as new demands placed on SMEs by intricate cross-border data management regulations, tightened global data privacy laws (e.g., GDPR, CCPA, PIPL) requiring business compliance focus, and data localization policies forcing SMEs to rely on localized cloud services from large companies, eroding their agile, flexible market competitiveness. Collectively, these factors depict a policy landscape filled with both opportunities and risks.

This driver is a foundational force shaping the entire system, interacting intensely with almost all others. It directly defines the boundaries for Compliance, Security, and Legal Risks, profoundly influences the pace and direction of Technology Adoption and Cost Reduction (e.g., via subsidies affecting technology choice), its stability acts as a buffer against Global Systemic Risks, and it significantly shapes the scope for Funding and Financing Model Innovations (e.g., through industry funds guiding investment).

Consequently, for SMEs, a shift from passive compliance to active engagement and strategic management of this driver is imperative. A key insight is that SMEs should treat the policy and regulatory environment as a critical strategic variable, establishing ongoing monitoring mechanisms (e.g., using professional services or digital tools) to stay informed and adapt to regulatory changes. Furthermore, actively providing feedback on practical challenges related to compliance and accessing support through collective channels like industry associations can help advocate for a more favorable policy environment. When formulating digital transformation strategy, SMEs are advised to carefully consider the timing of policy incentives (e.g., subsidies, tax benefits) and the baseline of regulatory requirements (e.g., data privacy), striving to innovate within compliance boundaries while leveraging available support for growth.

[1] GDPR refers to the EU's General Data Protection Regulation; CCPA refers to the California Consumer Privacy Act; PIPL refers to China's Personal Information Protection Law.

▶ Sustainability Integration

This driver captures the significant pressure from investors, regulators, consumers, and core supply chain partners pushing SMEs to move beyond treating Environmental, Social, and Governance (ESG) considerations as optional add-ons. Instead, it necessitates the deep integration of ESG principles into core business operations and the value chain through digital means to achieve measurable and verifiable sustainable development. It manifests in two primary ways:

• **Firstly, through ESG-driven requirements for SMEs to prove sustainable sourcing through digital traceability, where market and regulatory actors mandate the use of digital traceability technologies to demonstrate supply chain sustainability;**

• **Secondly, through an increasing need for ethical responsibility to balance digital growth with environmental sustainability, reflecting societal expectations for businesses to fulfill their ethical duty by aligning their digital expansion with environmental sustainability.**

This signifies that sustainability has evolved into an integral component of the value proposition and a key determinant of core competitiveness for all enterprises, including SMEs.

This driver is highly dependent on and integrates several other drivers. It is a direct outcome of pressures from Market and Consumer Behavior Shifts (e.g., preference for green products) and Policy and Regulatory Frameworks (e.g., ESG disclosure rules). Its practical realization, however, is entirely contingent upon progress in Technology Adoption and Cost Reduction (e.g., affordable traceability tech) and overcoming Technology Implementation and System Integration Challenges (e.g., embedding ESG data flows). Furthermore, it is supported by developments in Funding and Financing Model Innovations (e.g., green finance).

Consequently, for SMEs, moving beyond a passive compliance mindset (compliance for compliance's sake) towards a proactive, value-oriented integration strategy is critical. The key insight is that SMEs should approach sustainability as a central objective and value orientation for their digital transformation, rather than an isolated compliance task. When planning digital projects, prioritizing technological solutions that can simultaneously enhance operational efficiency and generate positive ESG impact (e.g., using IoT for energy management optimization) is advisable. By embedding ESG requirements into the core of product design, supply chain management, and data strategy, SMEs can potentially transform this challenge into an opportunity to establish a solid competitive position within the emerging green economy.

▶ Ethical and Social Inclusivity Challenges

This driver refers to the potential for algorithmic bias, social inequity, and the digital divide to arise or be exacerbated during digital transformation, stemming from factors such as technological design, market forces, and social structures. It concerns the value orientation and social acceptability of the entire digital transformation process. Its manifestations include:

- **Algorithmic fairness and transparency becoming an industry focus, reflecting heightened societal attention to the ethical attributes of technology itself;**
- **Alongside this, structural challenges are highlighted, as global tech giants control core AI models, cloud platforms, and datasets, leading to SMEs facing high costs and technical barriers in accessing these new key factors of production, placing them at a disadvantage from the outset.**

This disadvantage is further evident in the low level of discourse power SMEs hold in industry standard-setting, potentially facing unfair competition. More profoundly, the transformation process risks excluding vulnerable groups, such as SMEs operated by individuals in remote areas, women, and older entrepreneurs, who face greater risks of digital exclusion, thereby exacerbating social inequality within the entire business ecosystem.

This driver is deeply intertwined with other factors in the system. It is both directly shaped by outcomes from Technology Adoption and Cost Reduction and the Policy and Regulatory Framework, while also influencing Market and Consumer Behavior Shifts (e.g., growing consumer concern for corporate ethics). Simultaneously, it is closely linked to Labor and Skills Transformation (e.g., fairness in skill acquisition).

Therefore, for SMEs, it is crucial to treat ethics and inclusivity as key components of long-term risk management and social license to operate, rather than considering them optional moral add-ons. A key insight is that SMEs are advised to consciously assess and mitigate potential biases and exclusion risks in their technology selection and process design. For instance, prioritizing fairness when using AI for recruitment or credit assessment. Furthermore, proactively considering serving vulnerable groups and promoting social inclusion as potential avenues for innovation and differentiation can not only mitigate risks but also potentially open new market opportunities, helping to build a sustainable competitive advantage.

▶ Reflection: A System of Interdependent Elements

This section has moved beyond merely identifying ten critical drivers of change that will shape the digital transformation landscape for SMEs. The analysis reveals that these drivers do not operate in isolation but form a complex, interdependent system where changes in one area create ripple effects across the entire ecosystem. To synthesize these findings and provide a clear strategic lens for stakeholders, they have been categorized within an overarching framework of Core Productive Elements and External Environmental Elements.

The analysis shows that these ten drivers influence SMEs' digital transformation at different levels:

• **Drivers such as Technology Adoption and Cost Reduction, Labor and Skills Transformation, Funding and Financing Model Innovations, and Technology Implementation and System Integration Challenges can be consolidated into the core productive elements of technology, digital talent, capital, infrastructure and data. These are the indispensable internal resources that SMEs must mobilize to undertake their transformation.**

• **Conversely, drivers such as Global Systemic Risks and Resilience Requirements, Policy Support and Regulatory Frameworks, Market and Consumer Behavior Shifts, Sustainability Integration, and Ethical and Social Inclusivity Challenges can be summarized as the external environmental elements of ecosystem (support networks) and governance & policy (rules and direction). These represent the external conditions that SMEs navigate during their digital transformation journey.**

Figure 6 provides a synthesized framework that captures this classification and, more critically, illustrates the dynamic interactions and feedback loops between these two categories. It shows how External Environmental Elements continuously shape the conditions for deploying Core Productive Elements, which in turn fuel the transformation process and generate outcomes that feedback to influence the external environment itself. This systemic view is critical for developing effective and adaptive strategies.

Figure 6: A Framework of Interacting Elements
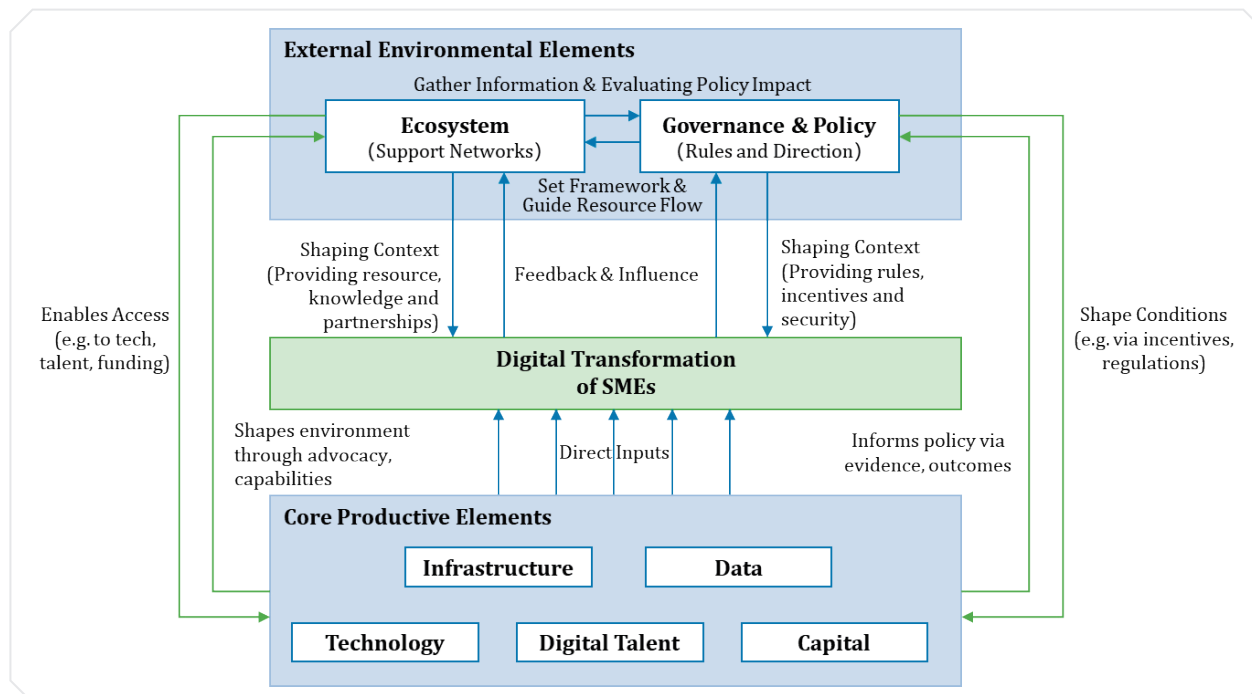
Source: CAICT

The analysis throughout this chapter reveals that the interactions between drivers are not merely linear but often form reinforcing loops and feedback cycles. This synthesis leads to a crucial strategic imperative: successful digital transformation requires a dual focus. SMEs and their supporting stakeholders cannot only look inward at building productive capacities, but also actively engage with the external environment. Strategy must be designed to:

• **Proactively manage and invest in the Core Productive Elements to build resilient internal capabilities;**

• **Actively engage with and seek to influence the External Environmental Elements through policy advocacy, industry collaboration, and adaptive planning.**

The scenario sets explored in the next chapter are, in essence, different configurations of how these ten drivers—through their interaction as Productive and Environmental Elements—might combine to create distinct futures for SMEs. Understanding this foundational structure is key to developing robust, resilient strategies capable of navigating the uncertainty ahead.

5. VISIONING THE FUTURE: THE POSSIBLE SCENARIOS

Having identified and analyzed the key drivers of change in Chapter 4, the focus now shifts to exploring how these drivers might interact to shape the future. This chapter presents the process of envisioning alternative futures for SMEs digital transformation by examining how selected drivers of change, and the interplay of their push and pull with each other, might interact over time. Through structured exploration, several scenarios are developed — each reflecting a different combination of technological feasibility, resource availability, and market dynamics. These scenarios are assessed for their implications, including potential operational strengths, strategic vulnerabilities, and broader knock-on effects on competitiveness. From this set of futures, a preferred scenario is identified, offering a shared vision to guide policy planning and enterprise-level decision-making.

▶ 5.1. Mapping the Spectrum of Possibilities

The digital transformation landscape for SMEs is explored through a range of diverse scenarios, each shaped by different combinations of the critical driver pairs. These drivers were then paired to reflect critical tensions or trade-offs likely to characterize the coming decade. These plausible futures span a wide spectrum—from optimistic and transformative to more challenging or stagnant trajectories. Each pair represents a distinct lens through which the future could evolve, producing a contrasting set of scenarios. Together, these scenario sets allow stakeholders to stress-test current strategies, anticipate divergent pathways, and design interventions that are both effective and resilient.

This conceptual approach is visualized in the deductive scenario matrix presented in Figure 7 below. Within each scenario set, the Scenario 3 represents a path of systemic decline or high risk, while the Scenarios 2 reflect a more transformative and desirable direction. Scenarios 1 and 4 also represent less desirable outcomes, often characterized by imbalances, inefficiencies, or missed opportunities.

Figure 7: Deductive Scenario Canvas – Methods and Illustration
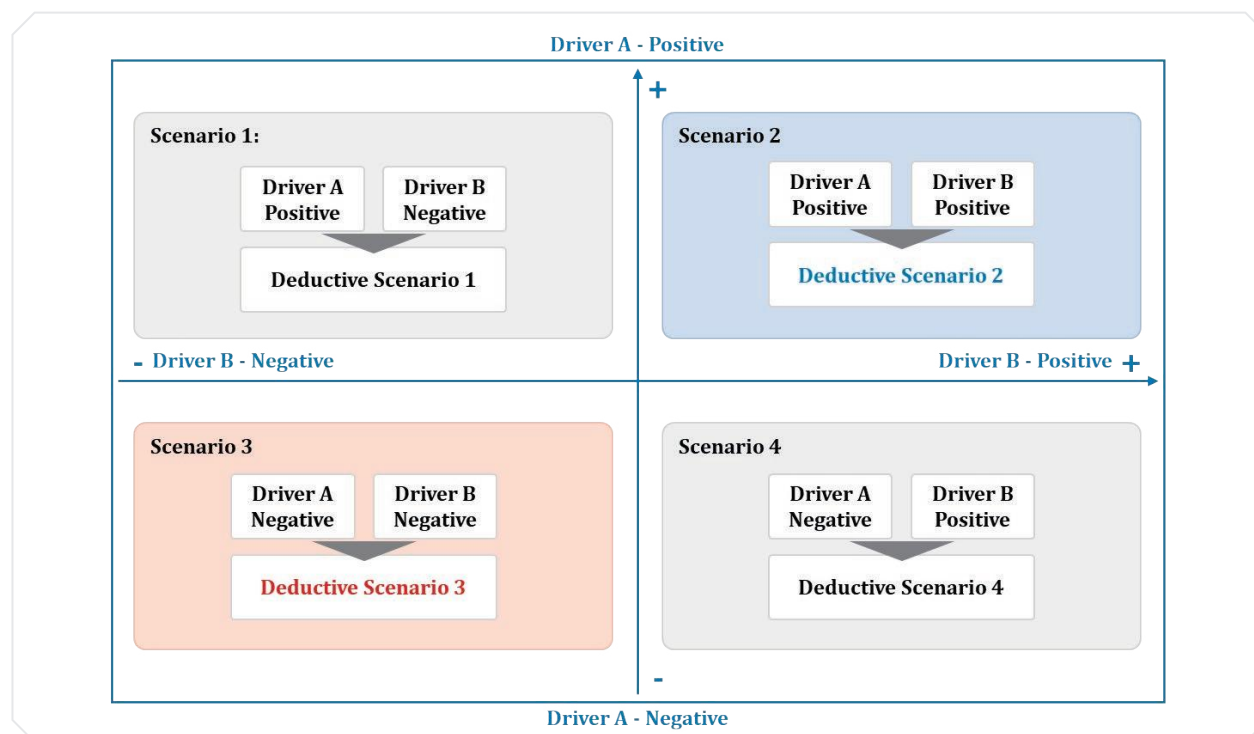
Source: ITU. Compiled by Authors

This matrix not only visualizes the scenario sets but also reveals a fundamental pattern: the most desirable and transformative scenarios consistently emerge from the synergistic combination of high performance across both driver pairs. Conversely, the most challenging futures arise from deficits in both dimensions. This underscores the imperative of addressing the core challenges in a coordinated manner.

The selection of these four specific driver pairs is directly informed by the analytical framework established in Chapter 4, which categorized the drivers into Core Productive Elements and External Environmental Elements. It examines how the interplay between Core Productive Elements and External Environmental Elements might configure to create divergent futures. The following driver pairs were selected to explore critical tensions along this internal–external axis:

• **Technology Adoption and Cost Reduction vs. Funding and Financing Model Innovations (Affordability vs. Liquidity):** This pairing probes the internal synergy within the Core Productive Elements, testing whether access to technology (a productive tool) is effectively enabled by the availability of capital (a productive resource).

- **Technology Implementation and System Integration Challenges vs. Labor and Skills Transformation (Technical Feasibility vs. Human Capital):** This pairing examines the internal alignment between two Core Productive Elements, assessing if the workforce's capabilities (human capital) are compatible with the technical demands of new systems (technology implementation).
- **Market and Consumer Behavior Shifts vs. Compliance, Security, and Legal Risks (Market Opportunity vs. Operational Risk):** This pairing explores a critical tension within the External Environmental Elements, analyzing whether the pull of market opportunities can outweigh the constraints and costs imposed by the regulatory and risk environment.
- **Policy Support and Regulatory Frameworks vs. Labor and Skills Transformation (External Enablement vs. Internal Capacity):** This pairing tests the efficacy of the interface between an External Environmental Element (policy support) and a Core Productive Element (human capital), analyzing whether external enablement can successfully build internal capacity.

Table 2: Key Scenario Sets

	Scenario Set 1	Scenario Set 2	Scenario Set 3	Scenario Set 4
	Affordability vs. Liquidity	Technical Feasibility vs. Human Capital	Market Opportunity vs. Operational Risk	External Enablement vs. Internal Capacity
Scenario 1	Tech Bubble Dilemma	Idling Engines	Innovation Cage	Grassroots Self-Rescue Breakthrough
Scenario 2	Inclusive Digitalization Era	Seamless Integration	Harmonious Coexistence	Synergistic Enablement & Prosperity
Scenario 3	Systemic Stagnation Crisis	Digital Islands	Suffocating Predicament	Systemic Failure
Scenario 4	Capital-Driven Application	Manual Workshop	Market Periphery	Tracks But No Train

Countries and sectors may find themselves on distinct trajectories depending on their specific context, institutional capacity, and policy choices.

Table 3 to Table 6 provide a snapshot of the deductive scenarios, and specifically describe and analyze each of the desirable futures.

Table 3: Scenario Set 1 – Affordability vs. Liquidity

Technology Adoption and Cost Reduction vs. Funding and Financing Model Innovations

Tech Bubble Dilemma	Inclusive Digitalization Era
High Affordability + Low Liquidity	High Affordability + High Liquidity
Although technology itself becomes highly affordable and available, SMEs remain constrained by cash flow pressures and still lack sufficient funds to adopt and implement digital technologies. A digital divide persists based on financial health rather than technological access.	Although technology itself becomes highly affordable and available, SMEs remain constrained by cash flow pressures and still lack sufficient funds to adopt and implement digital technologies. A digital divide persists based on financial health rather than technological access.
Systemic Stagnation Crisis	**Capital-Driven Application**
Low Affordability + Low Liquidity	Low Affordability + High Liquidity
SMEs face prohibitively high technological costs and barriers, coupled with stagnant financing channels. This toxic combination leads to a systemic stagnation in digital transformation, locking SMEs out of the modern digital economy.	Despite limited affordability of digital technologies, SMEs that secure funding through diversified, low-cost financing channels can achieve leapfrog development. This accelerates adoption but risks creating a two-tier ecosystem where only well-funded SMEs can compete.

Table 4: Scenario Set 2 – Technical Feasibility vs. Human Capital

Technology Implementation and System Integration Challenges vs. Labor and Skills Transformation

Idling Engines	Seamless Integration
Low Technical Feasibility + High Human Capital	High Technical Feasibility + High Human Capital
Despite having ample digital talent, SMEs are hampered by complex, non-interoperable technologies. Skilled employees are forced to create manual workarounds, leading to inefficiency and an inability to scale digitally.	Strong tech interoperability, coupled with ample digital talent, drastically lowers barriers to innovation and experimentation for SMEs. This synergy leads to rapid adoption, customization, and a significant competitive advantage.
Digital Islands	**Manual Workshop**
Low Technical Feasibility + Low Human Capital	High Technical Feasibility + Low Human Capital
Crippling talent shortages and complex, unwieldy technologies trap SMEs in a digital transformation dead end. They operate as isolated "digital islands", unable to connect efficiently with partners or supply chains.	Robust, user-friendly technologies are available, but a severe talent shortage forces SMEs into heavy reliance on external consultants. This creates vendor lock-in and prevents the development of in-house digital capabilities.

Table 5: Scenario Set 3 – Market Opportunity vs. Operational Risk

Market and Consumer Behavior Shifts vs. Compliance, Security, and Legal Risks

Innovation Cage	Harmonious Coexistence
High Market Opportunity + High Operational Risk	High Market Opportunity + Low Operational Risk
SMEs can access large digital markets but face complex compliance burdens and platform monopolies. To operate, they must adhere to restrictive rules that stifle innovation and prevent them from building independent brand value.	With access to guaranteed security, clear regulations, and interoperable standards, SMEs can rapidly validate new ideas and compete with large enterprises on a level playing field for innovation. Trust is high, and risks are manageable.
Suffocating Predicament	**Market Periphery**
Low Market Opportunity + High Operational Risk	Low Market Opportunity + Low Operational Risk
Market dominance by monopolies is high, and compliance costs are prohibitive for SMEs. This combination makes growth nearly impossible, further entrenching the market structure and leaving SMEs struggling to survive.	Subjected to limited market opportunities, SMEs are forced into a subsidiary status. They become marginalized suppliers to larger platforms, unable to enter mainstream markets or build their own brand value.

Table 6: Scenario Set 4 – External Enablement vs. Internal Capacity

Policy Support and Regulatory Frameworks vs. Labor and Skills Transformation

Grassroots Self-Rescue	Synergistic Enablement & Prosperity
Low External Enablement + High Internal Capacity	High External Enablement + High Internal Capacity
Even with uncoordinated policies and complex rules, market-driven training has created a base of tech talent. SMEs must rely on self-initiative and private sector networks to innovate, bypassing ineffective public support.	Coherent government policies lower costs and simplify market entry. These are perfectly complemented by a strong pipeline of digitally skilled workers from education systems. SMEs can innovate faster and compete effectively.
Systemic Failure	**Tracks But No Train**
Low External Enablement + Low Internal Capacity	High External Enablement + Low Internal Capacity
Crippling talent shortages and complex, unwieldy technologies trap SMEs in a digital transformation dead end. They operate as isolated "digital islands", unable to connect efficiently with partners or supply chains.	Government launches well-designed policies and subsidies, but a critical shortage of skilled workers prevents their effective implementation. SMEs see no benefits, face inflated talent costs, and the policy investment fails.

The screening process applied a dual criterion of plausibility (achievable through concerted action) and desirability (alignment with a shared vision of inclusive and sustainable digitalization). It is important to note that this evaluation was preceded by a comprehensive analysis of 15 potential driver pairs, which generated a wide-ranging portfolio of over 60 initial scenarios. All scenarios were mapped within the Futures Cone framework to assess their positioning. The final screening focused on the "plausible" and "preferable" domains of the Futures Cone framework (See Figure 8), ensured the selection of futures that are both realistic and ambitious.

Figure 8: Futures Cone

Source: Authors

▶ 5.2. Prioritizing the Desired Scenario

This section analyzes a wide range of scenarios to illustrate a spectrum of potential pathways for SMEs digital transformation, shaped by the varying intensity and interplay of critical drivers. The timeline for realizing these futures spans from the short to the long term, contingent upon the pace of technological advancement, policy breakthroughs, and workforce skills development. Against this backdrop of diverse possibilities, the potential impact of each scenario was rigorously assessed. A cautionary wild card scenario—depicting a plausible yet disruptive extension of current trends—was also incorporated to stress-test the resilience of preferred outcomes. From this comprehensive set of over 60 scenarios, a preferred scenario was identified that aligns with the shared aspiration of creating a vibrant, inclusive, and sustainable digital economy powered by empowered SMEs.

▶ **Establishing the Evaluation Framework: From Diagnosis to Criteria**

Prior to scenario evaluation, it is imperative to define the criteria for success. The seven core strategic goals against which the scenarios are assessed are not arbitrary. They are systematically derived from the foundational diagnosis and research mission articulated in this brief.

As established in Chapter 3, the persistent Triple Divide in technology access, financing, and skills constitutes the primary barrier to inclusive SMEs digitalization. Furthermore, the cross-cutting analysis of drivers in Chapter 4 highlighted interdependent challenges spanning technological adoption, regulatory compliance, and global market access. To address these multifaceted challenges, this research brief aims to move beyond symptomatic analysis towards enabling transformative and equitable outcomes.

Consequently, the evaluation framework is built upon the following seven interconnected strategic goals, which collectively translate the research problem into a set of positive, measurable aspirations. These aspirations are particularly important in the context of the topic of this foresight brief, as they capture the essential dimensions of how technology adoption, inclusivity, and resilience can shape sustainable growth for small and medium-sized enterprises in a rapidly evolving digital economy.

- **Strategic Goal 1 (SG.1):** SMEs ICT Adoption

Enhance the motivation of SMEs to adopt ICT technologies and provide them with more market development opportunities.

- **Strategic Goal 2 (SG.2):** Inclusive Growth

Achieve inclusive growth through digital transformation to prevent SMEs (especially those in developing countries) from being left behind in the wave of digital transformation.

- **Strategic Goal 3 (SG.3):** Local Digital Capabilities

Promote the cultivation of digital capabilities in developing countries that align with their own development needs, reduce reliance on single external technologies, and provide more development opportunities for SMEs in developing countries.

- **Strategic Goal 4 (SG.4):** Inclusive Standards

Advance the establishment of an inclusive, secure, open, and equitable global ICT technical standards framework to help lower the technical barriers for SMEs to access the global digital ecosystem.

- **Strategic Goal 5 (SG.5):** Global Cooperation

Foster an open, collaborative, and shared international digital innovation cooperation ecosystem to enhance the resilience of the global digital ecosystem.

- **Strategic Goal 6 (SG.6):** Market Entry & Resilience

Reduce market entry barriers, increase the diversity of economic entities, and enhance the resilience and efficiency of the economy.

- **Strategic Goal 7 (SG.7):** Lower Barriers for Innovation

Significantly lower the barriers and risks for SMEs to participate in digital transformation, and stimulate large-scale, diversified micro-level innovation.

These strategic goals serve as the guiding compass for our evaluation, ensuring that the prioritization of a desired scenario is aligned with the ultimate goal of the research brief — achieving a resilient, inclusive, and digitally empowered future for SMEs worldwide.

▶ **Evaluating the Scenarios: A Comparative Analysis**

The evaluation phase commenced by mapping each of the four shortlisted transformational scenarios against the seven core strategic goals. To rigorously stress-test the resilience of these preferred futures, a deliberately constructed wild card scenario ("The Asymmetric AI Divide") was incorporated into the analysis. This scenario was not drawn at random but was designed to extrapolate a disruptive yet plausible trajectory of current trends, wherein the concentration of AI capabilities exacerbates global digital inequalities.Some early-warning indicators for the wild card scenario include the introduction of data-localization bills across multiple jurisdictions within a 6-12 month period, platform policy changes that impose new cross-border fees fragmenting digital trade, and a rapid concentration of access to advanced computing power, creating a tangible barrier to entry.

As the comparative analysis reveals, while each scenario offers unique strengths and weaknesses, one demonstrates superior and balanced alignment across all seven strategic goals, even when contrasted with the challenging conditions of the wild card.

Table 7: Desired Scenario Analysis

	SG. 1: SMEs ICT Adoption	SG. 2: Inclusive Growth	SG. 3: Local Digital Capabilities	SG. 4: Inclusive Standards	SG. 5: Global Cooperation	SG. 6: Market Entry & Resilience	SG. 7: Lower Barriers for Innovation
Inclusive Digitalization Era	🙂	🙂	🙂	🙂	🙂	🙂	🙂
Seamless Integration	🙂	🙂	😐	🙂	😐	🙂	🙂
Harmonious Coexistence	😐	🙂	😐	🙂	🙂	🙂	😐
Synergistic Enablement & Prosperity	🙂	🙂	🙂	😐	😐	🙂	🙂
The Asymmetric AI Divide (Wildcard)	🙁	🙁	🙁	🙁	🙁	🙁	🙁

The comparative analysis presented in Table 7 yields a clear verdict: the "Inclusive Digitalization Era" scenario demonstrates the most robust and balanced alignment across all seven core strategic goals. It consistently outperforms other transformative scenarios and exhibits remarkable resilience. This decisive outcome establishes the "Inclusive Digitalization Era" not merely as a theoretical ideal, but as the most viable and strategic pathway forward. It is, therefore, selected as the preferred future worthy of in-depth examination in the following section.

▶ 5.3 Identifying the Desired Future

The comparative evaluation conducted in the previous section reveals a clear path forward. Among the diverse scenarios, the "Inclusive Digitalization Era" consistently demonstrated the most robust and balanced alignment with our strategic goals. This section transitions from evaluating possibilities to envisioning a realized outcome, zooming in on the structure and dynamics of this preferred future to understand how it fundamentally resolves the triple divide and achieves the strategic goals.

▶ Prioritizing the Scenario: Zoom In

In this preferred future, SMEs thrive in an ecosystem where digital tools are universally accessible and financial mechanisms are deeply inclusive. The "Inclusive Digitalization Era" scenario forms the foundational reality: technology adoption costs plummet to utility-like levels (Strategic Goal1), and data-driven financing models become mainstream, allowing SMEs of all sizes and from all regions to seamlessly onboard digital solutions.

This widespread adoption is not uniform but adaptive, fostering the Local Digital Capabilities (Strategic Goal 3) called for in our objectives. Developing countries cultivate digital skills and solutions tailored to their specific economic contexts, reducing dependency on singular external technologies and empowering local SMEs to innovate for local and global markets. This democratization of technology is underpinned by progress toward Inclusive Standards (Strategic Goal 4) and Global Cooperation (Strategic Goal 5). A framework of open, secure, and equitable technical standards lowers barriers to entry, while international collaboration ensures a resilient and interoperable global digital ecosystem. Within this supportive structure, SMEs experience a significant Lower Barriers for Innovation (Strategic Goal 7). The reduced cost and risk of digital experimentation unlock a wave of large-scale, diversified micro-innovations, enabling SMEs to rapidly find their Market Entry & Resilience (Strategic Goal 6). They compete not merely on cost but on agility and unique value propositions, thereby increasing the diversity and robustness of the entire economy.

Ultimately, this synergistic environment ensures the overarching goal of Inclusive Growth (Strategic Goal 2), preventing SMEs, particularly those in developing countries, from being left behind and instead positioning them as the dynamic core of a thriving global digital economy.

▶ **Enabling Factors That Support This Scenario**

The realization of the Inclusive Digitalization Era is not automatic but depends on the concerted development of several key enabling factors. These factors interact to create a self-reinforcing cycle that lowers barriers, fuels innovation, and ensures that the benefits of digital transformation are widely shared, directly supporting the core objectives of enhancing SMEs ICT adoption (Strategic Goal 1), fostering inclusive growth (Strategic Goal 2), and lowering barriers for innovation (Strategic Goal 7). Together, these enabling factors provide a direct pathway to positioning SMEs as dynamic innovators and resilient economic actors, ensuring they can access global markets, participate in collaborative ecosystems, and drive sustainable economic development.

Table 8: Key Enabling Factors for the Inclusive Digitalization Era

Enabling Factor	Rationale	Why This Matters for SMEs	KPI / Signpost (example)
Ubiquitous & Affordable Digital Infrastructure	Widespread deployment of high-speed broadband, cloud computing resources, and mobile networks—supported by public-private partnerships—ensures that even the smallest enterprises in remote areas can access powerful digital tools at low cost. This directly enables the "Inclusive Digitalization Era" by making technology adoption as easy and reliable as accessing a utility.	• Lowers the absolute barrier to entry (SG. 7), allowing SMEs to start their digital journey with minimal upfront investment. • Enhances market reach and operational efficiency (SG. 1, 6), enabling participation in the digital economy regardless of location.	• % of SMEs in rural/remote areas with access to affordable (>1% of revenue) high-speed broadband. • Average cost of basic cloud storage for micro-SMEs as a % of monthly revenue.
Data-Driven & Inclusive Financial Instruments	The development of innovative financing models, such as API-based lending that leverages SMEs' real-time operational data for credit scoring, provides the crucial liquidity needed to invest in technology. This tackles the core challenge of the "Tech Bubble Dilemma" scenario, ensuring that affordability translates into actual adoption.	• Solves the critical liquidity constraint, turning digital aspirations into actionable projects (SG. 1). • Fuels experimentation and micro-innovation by providing capital for testing new ideas, directly stimulating diversified innovation (SG. 7).	• % of SMEs successfully accessing sub-30-day digital credit based on real-time data. • Average cross-border payment cost for SMEs ≤ 3% for 2 consecutive quarters.

Enabling Factor	Rationale	Why This Matters for SMEs	KPI / Signpost (example)

Cohort-Based & Market-Aligned Skills Building	Moving beyond traditional training to dynamic, cohort-based learning models—often embedded within local innovation hubs—that are directly tied to market needs. This approach simultaneously builds "Local Digital Capabilities" (SG. 3) and ensures a steady pipeline of talent capable of driving and sustaining digital transformation within SMEs.	• Reduces the cost and risk of hiring and training for individual SMEs (SG. 7).
		   Equips SMEs with the in-house skills needed to implement and adapt digital solutions effectively, enhancing their competitiveness (SG. 1, 6).
			• % of SMEs participants in certified skills programs reporting increased digital tool adoption post-training.
			   Number of market-aligned digital curricula co-developed with industry associations.

Interoperable & Inclusive Technical Standards	The global and regional promotion of open, interoperable technical standards (SG. 4) prevents vendor lock-in, reduces system integration costs, and ensures that solutions developed in one context can be adapted in another. This foundational layer is critical for seamless operation within a framework of Global Cooperation (SG. 5).	• Lowers long-term technical complexity and cost (SG. 7). • Enables SMEs to easily connect to global platforms and supply chains (SG. 5, 6), facilitating market entry and resilience.	• % of newly registered SME-facing digital platforms offering open APIs. • Reduction in average system integration costs for SMEs adopting a second digital solution.
Adaptive & Transversal Policy Frameworks	Governments enacting policies that are developed "transversally" (across departments) and are adaptive to technological change. This includes regulatory sandboxes for testing new business models and digital-friendly procurement policies that create demand for SMEs innovations, directly supporting Market Entry & Resilience (SG. 6).	• Creates a predictable and supportive environment for digital investment. • Opens public sector markets to SMEs and de-risks innovation, encouraging broader participation and growth (SG. 1, 7).	• % of central government procurement value allocated to SMEs via digital platforms. • Existence of a functioning regulatory sandbox for fintech/e-commerce SMEs.

▶ Reflection:
From Scenario Exploration to a Desired Future

The exploration of the scenarios reveals a common truth: the future of SMEs digital transformation is not predetermined by technology alone. Instead, it will be forged in the interplay between the Internal Productive Capabilities that SMEs can muster and the External Environmental Conditions they operate within.

The most desirable futures, the Inclusive Digitalization Era, are characterized by environments that actively enable and de-risk investments in Core Productive Elements. This underscores the strategic imperative for policymakers and business leaders to not only focus on upgrading technology and skills but also to consciously design and advocate for the policies, financial mechanisms, and ecosystem partnerships that create a enabling environment for transformation to thrive.

6. ROADMAP FOR THE DESIRED FUTURE

This chapter translates the envisioned Inclusive Digitalization Era into a concrete and phased action plan. It synthesizes the temporal logic of the Backcasting Canvas with the strategic action domains of the Strategic Priority Matrix to construct a dynamic roadmap. This roadmap charts the course from overcoming the current Triple Divide in technology, funding, and skills toward the desired future where digital tools are accessible and financing is inclusive. The outcome is a practical guide for stakeholders to collaboratively close the gap between present challenges and a future of empowered, digitally transformed SMEs.

▶ 6.1. Building an Integrated Implementation Framework

The vision of an Inclusive Digitalization Era—where digital tools are as accessible as utilities and financing is seamlessly tied to data-driven performance—presents a profound shift from the current reality faced by SMEs. This reality is defined by the persistent Triple Divide in technology, funding and skills.

This Triple Divide is not a set of isolated challenges, but rather a system of interconnected constraints that can be diagnostically traced to deficits and misalignments across the core elements of the digital economy. Bridging this gap requires a deliberate, coherent, and sustained effort. It demands an integrated approach that addresses these elemental deficits simultaneously, rather than tackling the symptoms in isolation.

To operationalize this integrated approach, this chapter synthesizes the core analytical components into a dynamic action roadmap. This roadmap is designed to systematically resolve the interdependencies at the heart of the Triple Divide by sequencing interventions across time and strategic domains.

First, the Backcasting Canvas provides the temporal logic, sequencing the journey from the present to the desired future into five distinct yet interconnected phases. Each phase has a clear strategic objective, ensuring that near-term actions build the necessary foundation for long-term transformation. Second, the Strategic Priority Matrix supplies the strategic action domains, outlining the six key areas of intervention (including Innovation Dynamics, Innovation Capacity, Innovation of Key Sectors, Ecosystem Research, Ecosystem Knowledge Sharing and Ecosystem Partnership & Governance) that must be addressed comprehensively.

Figure 9 presents the roadmap as a three-stage evolution: from establishing a Policy Support System, to activating a Resource Integration Mechanism, and finally achieving Ecosystem Synergy. It illustrates how the strategic focus shifts sequentially from building foundational capacities, to unlocking financial resources, and ultimately to stimulating endogenous growth.

Figure 9: The Integrated Action Roadmap
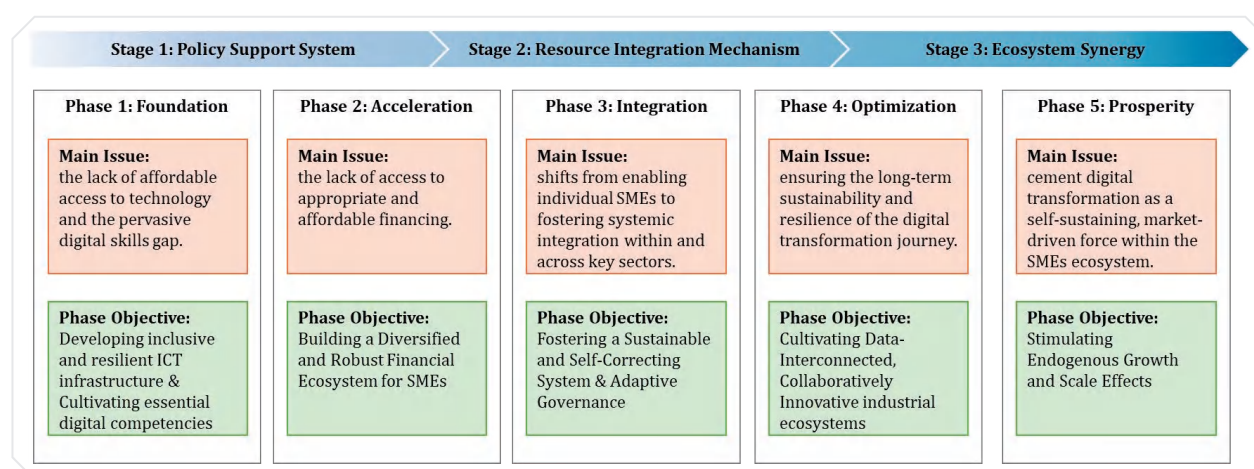
Source: Authors

The following sections will detail this pathway phase by phase, outlining the key initiatives that, through the coordinated efforts of all stakeholders, can guide SMEs towards the Inclusive Digitalization Era.

▶ 6.2. Phase 1:
Foundation–Bridging the Access and Skills Divide

The initial phase of the roadmap addresses the most immediate barriers to digital transformation: the lack of affordable access to technology and the pervasive digital skills gap. The primary objective is to create a foundational level playing field by developing inclusive and resilient ICT infrastructure and cultivating essential digital competencies among SMEs and the workforce.

This objective is achieved by strategically activating and coordinating a core set of productive and external environment elements. The phase primarily focuses on strengthening the Infrastructure (e.g., networks, edge computing), building Digital Talent (through training and local support), and lowering the cost of Technology adoption (via vouchers and open-source platforms). These efforts are orchestrated and de-risked by a foundational Governance & Policy framework, while simultaneously seeding the future potential of the Ecosystem elements through initial knowledge-sharing and innovation initiatives.

This phase is critical for building trust and demonstrating the tangible value of digitalization, thereby setting the stage for more advanced adoption in subsequent phases. The strategic focus lies primarily on establishing effective Ecosystem Partnership & Governance and building core Innovation Capacity.

The logical flow of Phase 1—how targeted initiatives address the divides, activate core elements, and interconnect to achieve the phase objective—is synthesized in Figure 10.

Figure 10: Phase 1 Strategic Logic-From Initiatives to Foundational Outcomes
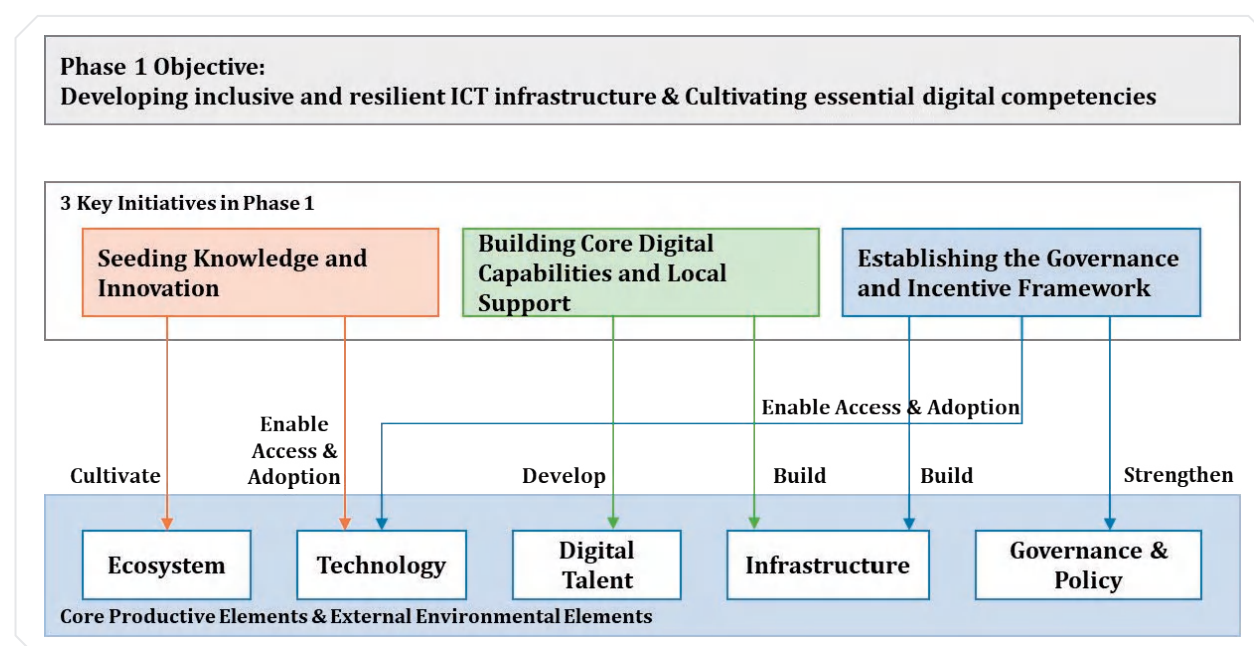
Source: Authors

Key initiatives in this phase are strategically aligned to tackle the core divides:

▶ **Seeding Knowledge and Innovation**

This set of initiatives focuses on lowering technical barriers and accelerating knowledge sharing, aiming to create a virtuous cycle: improved access promotes skills development, which in turn drives demand for better tools and services. By systematizing reusable resources and building experimental environments, these initiatives help SMEs reduce development costs, foster a community-driven learning culture, and provide a knowledge foundation for deeper transformation in subsequent phases.

(1) Build an open-source and sharing platform for digital technologies: Providing open-source tools, APIs, and a case study library systematically reduces development costs and accelerates peer-to-peer learning within the SMEs community.

(2) Study knowledge flow mechanisms in SMEs ecosystems: Early-stage research into how knowledge is shared among SMEs helps identify effective patterns for community-driven learning, informing the design of more effective support mechanisms in later phases.

(3) Research on low-code/no-code technology empowerment in ecosystems: Focus on the application of low-code tools in SMEs digitalization, studying their impact on reducing technical barriers, reshaping business processes, and lowering ecosystem participation thresholds (e.g., enabling SMEs to independently develop lightweight applications). Establish experimental environments for SMEs to test and provide feedback, mapping new stakeholder roles (e.g., citizen developers, ecosystem integrators) and resource interaction processes under technology empowerment.

(4) Build a low-code/no-code technology enablement platform: Systematize reusable digital resources within the region/industry (e.g., open-source tools, common technology modules, service provider capability lists). Construct a low-code/no-code technology enablement platform to provide technical support for SMEs.

(5) Foster a "small, swift, simplified, and targeted" supply ecosystem: Small refers to modularizing and componentizing complex solutions, enabling SMEs to flexibly choose and deploy on demand. Swift emphasizes that solutions can be quickly launched, deployed and deliver results. Simplified aims to reduce the resource occupation and implementation threshold of products, making it easier for enterprises to operate efficiently and reduce operational burdens. Targeted focuses on the specific business scenarios of enterprises, precisely addressing pain points to avoid "large and complete" solutions that fail to match with actual needs.

▶ **Building Core Digital Capabilities and Local Support**

This group of measures is dedicated to establishing localized digital infrastructure and support systems. By promoting lightweight edge cloud, digital service centers, and skills training platforms, it enhances SMEs' internal capabilities and sustainability. These actions directly address the skills and infrastructure gaps, ensuring that SMEs have access to practical technical support and human resources. Through collaboration and localized cultivation, the initiatives aim to reduce dependence on centralized resources and foster a self-sufficient local digital ecosystem, providing solid support for deep-level transformation.

(1) Promote the construction of "Lightweight Edge Cloud" and community shared computing centers: The government or community organizations will lead the establishment of shared edge computing nodes in industrial parks to provide local data storage and basic computing services. Simultaneously, promote containerized, lightweight cloud-native applications to reduce reliance on continuous high-speed network connectivity.

(2) Establish regional digital-service hubs: These hubs provide shared technical support, secure operations, and compliance advice, offering SMEs a physical or virtual one-stop-shop to solve common implementation problems, thereby reducing the perceived risk and complexity of digitalization.

(3) Build a digital-skills training platform for SMEs: Partnering universities with industry to develop modular, low-cost online courses focused on practical skills (e.g., data analytics, AI-tool usage) is crucial for building the internal human capital needed for deep digital transformation.

(4) Launch a digital skills training and certification initiative: Collaborate with educational institutions and online learning platforms to provide structured training courses and certification programs in key digital areas (e.g., data analysis, cloud computing, cybersecurity). Through this initiative, offer a mentor network and skill qualification certification for local talent, thereby cultivating local technical expertise.

(5) Cultivate a localized talent team for ICT infrastructure operation, maintenance, and support: Collaboration with vocational institutions to offer practical courses ensures the availability of local technical expertise to operate and maintain the newly established digital infrastructure, fostering sustainability.

▶ **Establishing the Governance and Incentive Framework**

This set of initiatives creates a supportive environment through policy guidance and financial incentives, addressing the access and trust gaps. Utilizing Public-Private Partnership (PPP) models, tax incentives, and technology voucher programs, these actions directly lower the threshold and compliance costs of digital transformation for SMEs. By ensuring network coverage and streamlining approval processes, the initiatives aim to stimulate initial demand and experimentation, laying an institutional foundation for scaled innovation in subsequent phases.

(1) Implement a "Last-Mile Connectivity" universal network coverage plan: Utilizing Public-Private Partnership (PPP) models, this initiative aims to provide affordable network access to industrial parks in rural and remote areas, directly addressing the physical access divide.

(2) Develop a dedicated policy framework for the digital transformation of SMEs: A clear policy roadmap, encompassing tax incentives, procurement preferences, and streamlined approval processes, is essential to reduce compliance costs and lower market-entry barriers, creating an immediate supportive environment.

(3) Roll out a "Technology Voucher" program: Subsidized vouchers that SMEs can redeem for cloud services, SaaS tools, and digital-transformation consulting effectively lower the upfront cost of technology adoption, stimulating initial demand and experimentation.

Phase 1 marks the starting point of the digital transformation roadmap. Through concentrated efforts on these fundamental initiatives, this phase aims to create a virtuous cycle: improved digital access promotes skills development, which in turn drives demand for better tools and services. Key success indicators include increased digital connectivity, growth in the base of digitally literate SMEs and workers, and the emergence of a supportive local ecosystem. This phase effectively paves the way for the financial and integrative innovations of the next phase, ensuring that the entire transformation process starts from a solid foundation and moves toward inclusive and sustainable growth.

▶ 6.3. Phase 2: Acceleration-Building a Diversified Financial Ecosystem

Building upon the foundational infrastructure and initial digital capacity built in Phase 1, this phase tackles one of the most critical barriers to deep digital transformation: access to appropriate and affordable financing. The central objective is to establish a diversified and robust financial services ecosystem tailored to the unique needs of SMEs in the digital economy. The goal is to shift from traditional, collateral-based lending to innovative models that recognize and value SMEs' data assets and digital potential.

This objective is achieved by strategically activating and coordinating a new set of productive and external environment elements, with a primary focus on unlocking the flow of Capital through innovative financial products and risk-sharing mechanisms. These efforts are enabled and de-risked by advanced Governance & Policy frameworks that legitimize data as an asset and create a safe space for innovation (e.g., regulatory sandboxes). Simultaneously, this phase begins to operationalize Data as a key factor of production and leverages Ecosystem platforms to enhance market transparency and resource matching.

This phase is pivotal for translating initial digital capabilities into tangible economic value, thereby creating the financial fuel for more significant, integrated transformation projects in subsequent phases. The strategic focus expands from the foundational capacity built in Phase 1 to actively shaping Innovation Dynamics through policy and market creation, while initiating structured Ecosystem Knowledge Sharing.

The logical flow of Phase 2—how targeted initiatives create the policy preconditions, develop innovative financial instruments, and enhance market efficiency to achieve the phase objective—is synthesized in Figure 11.

Figure 11: Phase 2 Strategic Logic-From Initiatives to a Diversified Financial Ecosystem
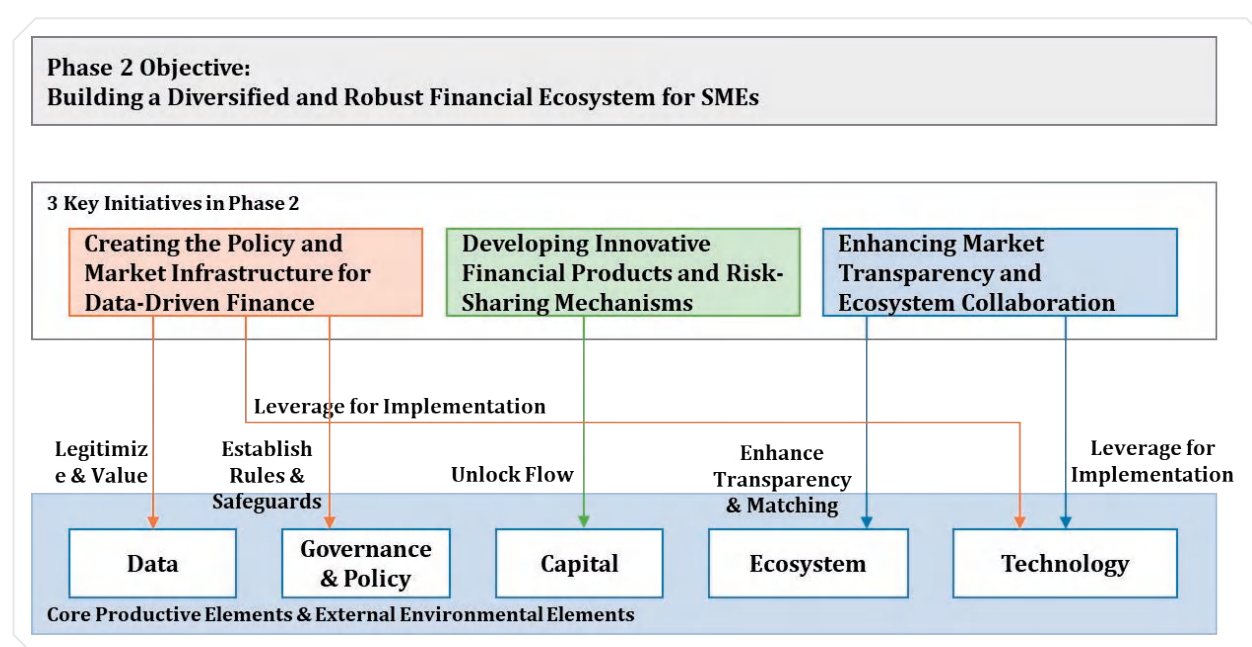
Source: Authors

Key initiatives in this phase are designed to create a supportive financial environment through targeted policy, innovative products, and enhanced market transparency:

▶ **Creating the Policy and Market Infrastructure for Data-Driven Finance**

This set of initiatives focuses on establishing policy frameworks and market infrastructure for data as a factor of production, aiming to build a secure and transparent environment that ensures effective utilization of data in financial applications, thereby providing institutional safeguards for SMEs' digital transformation.

(1) Advance market-oriented policies for data as a factor of production: Clarifying rules on data ownership, circulation, and trading is the critical first step to enabling SMEs to convert their operational data flows into trusted, bankable assets for financing and commercial partnerships.

(2) Develop and promote data trust and security governance frameworks: Establishing robust frameworks for data trust and security is essential to build confidence among all stakeholders (SMEs, financial institutions, regulators) in sharing and utilizing data for financial purposes.

(3) Create a regulatory sandbox mechanism: This provides a safe space for financial institutions and fintech companies to test innovative products and services (e.g., based on data monetization and AI) under temporary regulatory exemptions, fostering responsible innovation in the financial sector.

(4) Dynamic monitoring and research on digital policies: Tracking and analyzing the impact of digital policies across regions helps refine sandbox mechanisms and other policy tools, ensuring they effectively support SMEs digitalization without unintended consequences.

▶ **Developing Innovative Financial Products and Risk-Sharing Mechanisms**

This group of measures is dedicated to developing specialized financial products tailored for SMEs' digital transformation and lowering financing thresholds through risk-sharing mechanisms. These efforts aim to alleviate traditional financing barriers, encourage SMEs to invest in their digital journey, while simultaneously promoting sustainable and inclusive growth.

(1) Establish an SMEs credit risk sharing mechanism: Developing a framework where governments, financial institutions, and guarantee agencies collaboratively assume partial credit risks directly alleviates lenders' concerns, encouraging them to serve SMEs they would otherwise deem too risky.

(2) Encourage financial institutions to develop digital transformation financial products: These specialized products assess a company's digital maturity and potential, rather than relying solely on historical financial statements, creating a direct financial incentive for SMEs to invest in their digital journey.

(3) Develop a lightweight supply chain finance platform: Leveraging technologies like blockchain, this initiative supports core enterprises in extending their credit to multi-tier suppliers within the chain. It provides pledge financing and quick liquidation for key SMEs, effectively addressing their lack of traditional collateral.

(4) Implement an inclusive digital finance incentive mechanism: Offering fast-track loan approval or preferential interest rates to SMEs that adopt green technologies or promote inclusivity links financial incentives directly to broader societal goals, channeling capital toward sustainable and equitable digital growth.

▶ **Enhancing Market Transparency and Ecosystem Collaboration**
This set of initiatives enhances market transparency and capital allocation efficiency by establishing investment matching platforms, digital transformation evaluation systems, and multi-stakeholder collaborative governance. Leveraging AI technologies and standardized assessments, these actions reduce information asymmetry and ensure alignment between financial policies and SMEs' needs. Through promoting ecosystem collaboration, these measures aim to create an efficient, transparent financing environment that accelerates SMEs' access to diversified funding sources.

(1) Create an ecosystem project investment and financing matching platform: An online platform that uses AI-based matching to connect viable SMEs digital transformation projects with investors, grant providers, and venture capitalists significantly improves the efficiency of capital allocation and increases SMEs' access to diverse funding sources.

(2) Establish and improve the digital transformation evaluation system for SMEs: Collaborating with research institutions to develop a credible evaluation system provides a standardized basis for assessing SMEs digital maturity, which informs policy, guides enterprise self-diagnosis, and reduces information asymmetry for financiers.

(3) Establish a "Government-Bank-Enterprise-Research" digital collaboration governance and resource matching platform: This initiative formalizes multi-stakeholder dialogue and coordination, ensuring that financial policies and products are well-aligned with the evolving needs of SMEs and the capabilities of the ecosystem.

The successful implementation of Phase 2 marks a pivotal shift. It moves the ecosystem from providing basic digital access to creating a financial environment that actively fuels and de-risks digital investments for SMEs. By unlocking capital flows tied to digital progress, this phase enables SMEs to embark on more significant, integrated transformation projects, setting the stage for the sector-specific deep dives and data-driven collaboration that characterize the next phase of the roadmap.

▶ 6.4. Phase 3: Integration–Cultivating Data-Interconnected Ecosystems

With foundational infrastructure in place and financial mechanisms maturing, the roadmap enters a phase focused on deepening the impact of digitalization. The objective here shifts from enabling individual SMEs to fostering systemic integration within and across key sectors. The goal is to cultivate "data-interconnected, collaboratively innovative" industrial ecosystems where data flows securely to optimize value chains, spur co-innovation, and create new sources of competitive advantage.

This objective is achieved by strategically activating and coordinating a set of productive and external environment elements, with a primary focus on strengthening Ecosystem platforms for sector-wide collaboration, establishing robust Governance & Policy frameworks for data sharing, and leveraging Technology and Data as key enablers. These efforts are supported by enhancing Digital Talent and fostering knowledge exchange, ensuring that integration is both practical and sustainable.

This phase is critical for translating digital capabilities into tangible value at the ecosystem level, thereby creating a foundation for the adaptive governance and endogenous growth of subsequent phases. The strategic focus intensifies on Innovation of Key Sectors and leverages deeper Ecosystem Research to guide targeted interventions.

The logical flow of Phase 3—how targeted initiatives address the integration challenges, activate core elements, and interconnect to achieve the phase objective—is synthesized in Figure 12. This flow illustrates how sector-specific pilots demonstrate value, data standards enable trust and interoperability, and collaborative mechanisms foster innovation, collectively cultivating data-interconnected ecosystems.

Figure 12: Phase 3 Strategic Logic- Cultivating Data-Interconnected Ecosystems
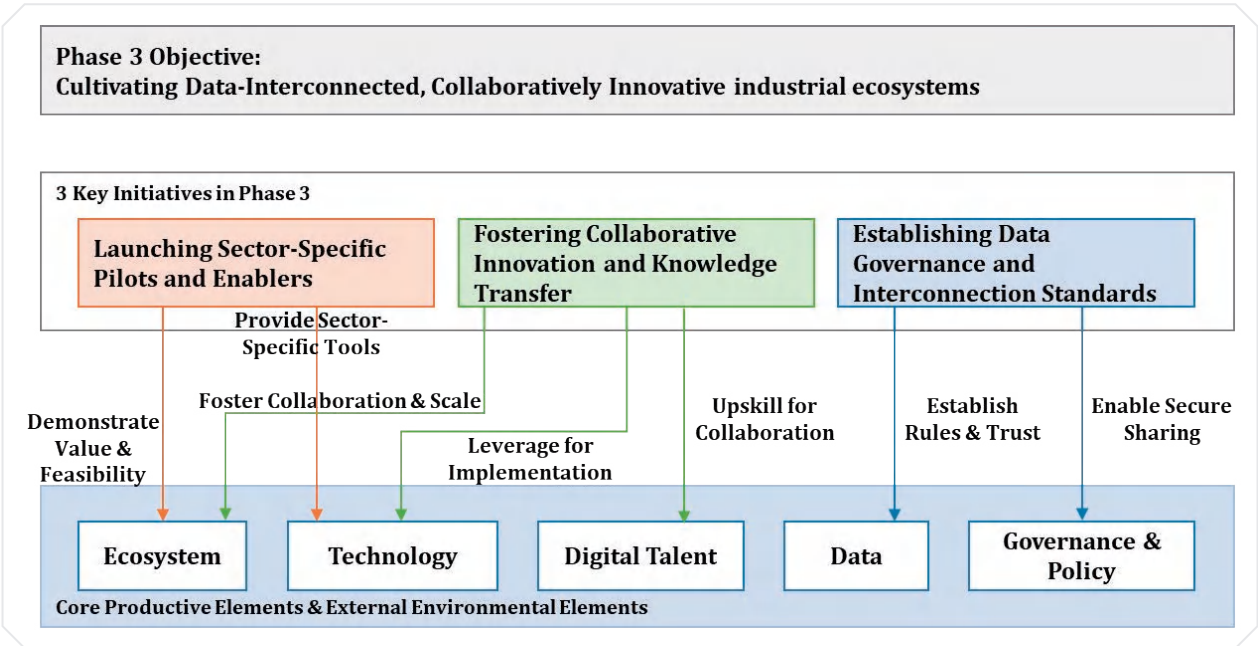
Source: Authors

This phase moves beyond point solutions to orchestrate sector-wide transformation through the following key initiatives:

▶ **Launching Sector-Specific Pilots and Enablers**

This set of initiatives focuses on conducting in-depth transformation pilots in industries with dense concentrations of SMEs, generating replicable deep integration models. By developing industry-specific transformation roadmaps and establishing industry digital innovation centers, it provides clear technical pathways for SMEs. These efforts demonstrate the value of transformation to guide followers in achieving scale effects, while overall reducing the technical barriers for SMEs through practical tools such as providing industry-specific open-source AI models.

(1) Launch sector-specific pilots for digital transformation: Focusing on industries with dense SMEs populations (e.g., manufacturing, retail), this initiative aims to create flagship cases—such as digital twins and flexible production systems—that generate tangible, replicable models of deep integration, demonstrating value and reducing perceived risk for followers.

(2) Develop digital transformation roadmaps for key industries: For each priority sector, detailed roadmaps created by experts provide SMEs with clear guidance on technology selection, investment budgets, and compliance standards, demystifying the transformation journey and enabling coordinated action across the ecosystem.

(3) Establish industry digital innovation centers: Physical centers located in key industrial clusters provide industry-specific R&D, testing, and training services (e.g., AI quality inspection for textiles, blockchain traceability for food), acting as hubs for applied innovation and knowledge dissemination.

(4) Develop industry-specific open-source large AI models: Provide access to tailored, cost-effective AI tools, lowering the barrier for SMEs to integrate advanced AI capabilities.

▶ **Fostering Collaborative Innovation and Knowledge Transfer**

This group of measures promotes collaborative problem-solving among SMEs, universities, and research institutions by hosting industry innovation challenges, establishing joint R&D mechanisms, and leveraging the experiences of successfully transformed SMEs owners. By creating open-source Transformation Case Libraries and Best Practice Knowledge Bases, and building knowledge-sharing platforms for vertical industries, it accelerates knowledge dissemination and talent development. These actions aim to pool resources to address common industry challenges that individual SMEs cannot tackle alone, while accelerating the transformation process through peer validation.

(1) Host "Industry Innovation Challenges" and establish joint R&D mechanisms: By identifying and funding solutions to common industry technical problems (e.g., "digital monitoring of textile printing and dyeing wastewater"), this initiative stimulates collaborative problem-solving between SMEs, universities, and research institutes, pooling resources to address challenges too large for any single SME.

(2) Encourage SMEs that have successfully transitioned to share their experiences : Enabling these pioneers to share real-world experiences and lessons learned through workshops provides invaluable, peer-based validation and practical insights, accelerating the adoption curve for other SMEs in their sector.

(3) Create an open-source "Transformation Case Library" and best practices knowledge base: Build a repository of case studies and best practices to accelerate learning and adoption within the SMEs community. Create industry-vertical "Digital Transformation Practice" open-source communities and knowledge platforms. Establish platforms for continuous knowledge exchange and collaboration within specific industries.

(4) Foster a composite talent team for industrial digital ecosystem operation and management: Partner with universities to establish specialized programs that cultivate interdisciplinary talents skilled in industrial technology, data management, and ecosystem operations. These talents will be deployed to key industrial clusters.

▶ **Establishing Data Governance and Interconnection Standards**

This set of initiatives breaks down data silos and creates technical prerequisites for seamless data exchange by formulating industry data interconnection standards and certification systems. Through pilot programs for Data Trust governance models and promoting the development of industry data spaces, it addresses data ownership and privacy concerns, building the trust foundation necessary for SMEs to participate in data sharing. These measures aim to make data not only a strategic asset for individual enterprises but also a cornerstone for enhancing collaborative efficiency and innovation capabilities across the entire industry community.

(1) Formulate industry data interconnection standards and a certification system: Government-led development of unified data formats and secure transmission protocols is essential to break down data silos. A data readiness certification incentivizes compliance and ensures interoperability, creating the technical preconditions for seamless data exchange.

(2) Establish pilot programs for a Data Trust governance model in key industries: Setting up neutral third-party institutions to manage and authorize the use of shared data on behalf of member enterprises addresses critical concerns over data ownership and privacy. This governance model builds the trust necessary for SMEs to participate confidently in data-sharing initiatives.

(3) Promote the development of industry data spaces: Encouraging secure data-sharing among peers or across supply-chain tiers enables transformative practices like joint demand forecasting and shared capacity planning, raising the overall coordination and resilience of the entire sector.

Phase 3 marks a critical evolution from building generic capabilities to catalyzing sector-specific, data-driven value creation. Success in this phase is evident when data becomes a strategic asset not just for individual firms, but for entire industrial communities, unlocking efficiencies and fostering innovation at a scale previously unattainable. This sets the foundation for the adaptive, self-sustaining ecosystem envisioned in the next phase.

Box 8: Digital Full-Process Work Management Platform

Shenzhen Chuangshi Hulan Technology's Digital Full-Process Work Management Platform

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Key Challenge: Inefficient digital project management, characterized by redundant approvals, fragmented oversight, and difficulty in knowledge reuse, undermined the success of SMEs' digital transformation.

ICT Solution: An integrated platform that manages the entire project lifecycle—from demand planning and costing to implementation and code hosting—ensuring end-to-end visibility and control.

Outcomes Breakdown: Reduced data entry time by 70%, shortened the cost accounting cycle to weekly, and decreased material shortage-related downtime by 80%.

Reference Value: This case demonstrates how breaking down data silos and achieving seamless system integration creates a closed-loop, data-driven management system that is essential for cultivating data-interconnected ecosystems.

▶ 6.5. Phase 4: Optimization–Refining Adaptive Governance

Having established data-interconnected ecosystems in key sectors, the roadmap enters a phase dedicated to ensuring the long-term sustainability and resilience of the digital transformation journey. The primary objective is to evolve from building discrete capabilities to fostering a holistic, sustainable and adaptive digital transformation service and governance system. The goal is to shift from implementing predefined initiatives to cultivating an ecosystem capable of self-correction, continuous learning, and agile evolution in response to technological shifts and global dynamics.

This objective is achieved by strategically activating and coordinating a mature set of productive and external environment elements, with a primary focus on leveraging Data and advanced Technology (e.g., AI, digital twins) as core inputs for strategic foresight and ecosystem intelligence. These efforts are enabled and de-risked by sophisticated Governance & Policy frameworks that institutionalize ethical standards, adaptive regulation, and multi-stakeholder dialogue. Simultaneously, this phase deepens Ecosystem partnerships and knowledge sharing to integrate global best practices and professionalize governance capabilities.

This phase is pivotal for transitioning the ecosystem from externally guided transformation to an internally sustained, self-improving system, thereby creating a resilient foundation for the final, market-driven phase of endogenous growth. The strategic focus intensifies on maturing Ecosystem Partnership & Governance and leveraging deep Ecosystem Research to inform a dynamic, learning-oriented governance model.

The logical flow of Phase 4—how targeted initiatives institutionalize learning, strengthen adaptive governance, and foster global integration to achieve the phase objective—is synthesized in Figure 13.

Figure 13: Phase 4 Strategic Logic–Refining Adaptive Governance
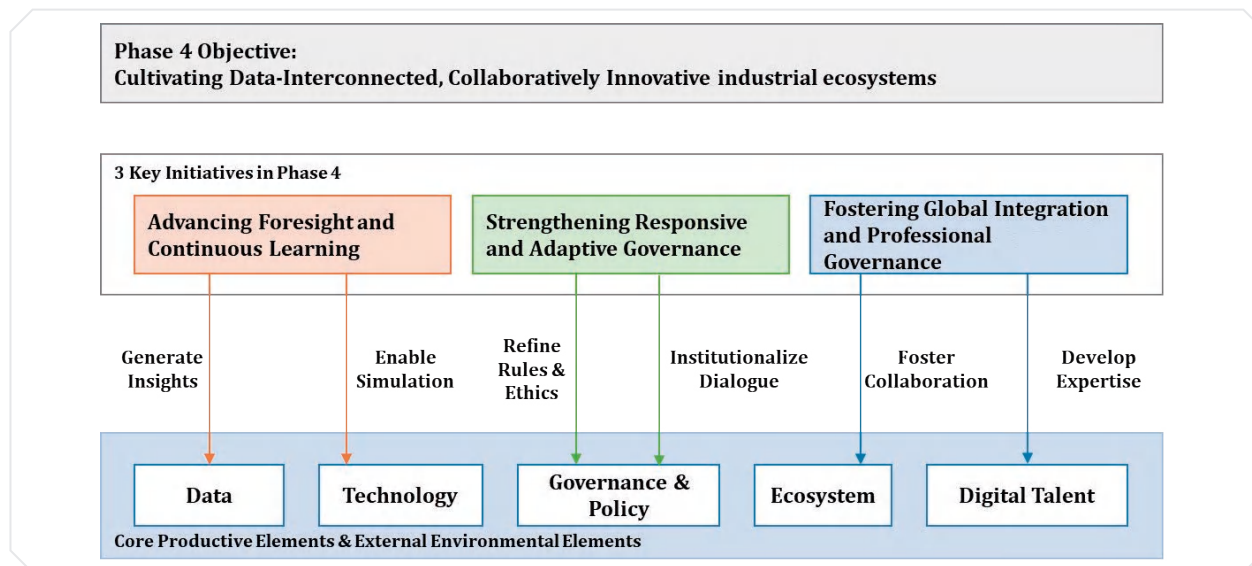
Source: Authors

Key initiatives in this phase are designed to embed intelligence, responsibility, and adaptability into the core of the ecosystem through enhanced foresight, ethical frameworks, and professionalized collaboration:

▶ **Advancing Foresight and Continuous Learning**

This set of initiatives focuses on enhancing the ecosystem's foresight and continuous learning capabilities through dynamic monitoring platforms, maturity benchmarking, and foresight research. By integrating real-time data, AI technologies, and digital twins, it provides data-driven decision support, simulating and predicting ecosystem-wide impacts. Additionally, through cross-regional comparative studies and the localization of international best practices, it optimizes local strategies and identifies global benchmarks, ensuring the ecosystem can anticipate future opportunities and challenges, enabling strategic preparation rather than reactive responses.

(1) Establish a dynamic monitoring platform for digital transformation: Integrating real-time economic, industrial, and policy data with digital twin and AI technologies enables the simulation and prediction of ecosystem-wide impacts. This provides policymakers and ecosystem orchestrators with a data-driven dashboard for evidence-based decision-making and early warning of systemic risks or bottlenecks.

(2) Establish a digital transformation maturity benchmarking and continuous tracking mechanism for SMEs: This mechanism provides a standardized framework to regularly assess and track the digital maturity of SMEs over time. It offers vital data for measuring progress, identifying support needs, and informing policy adjustments.

(3) Conduct foresight research and impact assessment on cutting-edge technologies:
Proactive analysis of the implications of emerging technologies (e.g., advanced AI,
privacy-preserving computation) for SMEs ensures that the ecosystem anticipates future
opportunities and challenges, allowing for strategic preparation rather than reactive scrambling.

(4) Conduct cross-regional comparative studies on SMEs digital ecosystems: By analyzing
policies and collaboration models in diverse international contexts, this research generates
invaluable insights for optimizing local strategies, identifying global best practices, and refining
models of stakeholder interaction under different institutional frameworks.

(5) Researching on introducing and localizing international digital ecosystem best practices:
This initiative involves studying the operational mechanisms and key stakeholder models of
leading global digital ecosystems. Through case analysis, it assesses the feasibility of adapting
these international experiences to the local context, refining strategies for cross-border
collaboration and resource integration.

▶ Strengthening Responsive and Adaptive Governance

This group of measures aims to strengthen the responsiveness and adaptability of governance
through responsible AI and data ethics governance frameworks, policy regulatory sandboxes, and
multi-stakeholder dialogue mechanisms. By formalizing and implementing ethical guidelines, it
ensures SMEs' digital practices remain transparent, fair, and accountable, mitigating risks related
to privacy and algorithmic bias while building long-term societal trust. Simultaneously, it promotes
innovation and manages risks in a dynamic environment through iterative optimization of
regulations.

(1) Develop and promote a responsible AI and data ethics governance framework: As
digitalization deepens, formalizing and implementing guidelines for ethical AI use and data
governance becomes paramount. This ensures that SMEs digital practices remain transparent, fair,
and accountable, mitigating risks related to privacy and algorithmic bias and building long-term
societal trust.

(2) Build a digital policy regulatory sandbox: This mechanism allows for the testing of new
policy combinations in a controlled environment. By monitoring their impact on ecosystem vitality,
policymakers can iteratively optimize regulations, fostering innovation while managing risk in a
dynamic landscape.

(3) Establish regular, multi-level "Government-Bank-Enterprise-Research" dialogue mechanisms: Formalizing ongoing, structured dialogue among key stakeholders ensures that governance remains responsive to on-the-ground challenges and opportunities, facilitating continuous alignment and coordinated adaptation of strategies.

▶ **Fostering Global Integration and Professional Governance**

This set of initiatives promotes global integration and professional governance through international partnership programs and professional talent systems. By organizing regular international workshops and collaboration projects, it facilitates the exchange of knowledge, resources, and best practices, integrating the local ecosystem into the global digital economy and providing SMEs with access to international networks and opportunities. Furthermore, by collaborating with universities to cultivate professionals skilled in technology, management, and public policy, it ensures the long-term sustainability of ecosystem governance.

(1) Launch an international partnership program for digital transformation: Regular international workshops and collaboration projects enable the exchange of knowledge, resources, and best practices, integrating the local ecosystem into the global digital economy and providing SMEs with access to international networks and opportunities.

(2) Build and enhance a professional talent system for digital transformation governance:
Collaborating with universities to cultivate a new cadre of professionals skilled in technology, management, and public policy ensures that the complex task of operating and optimizing the ecosystem's governance is in capable hands, guaranteeing its long-term sustainability.
Phase 4 represents the maturation of the digital transformation ecosystem. It shifts the focus from launching initiatives to optimizing a coherent, learning-oriented system. Success in this phase is measured by the ecosystem's enhanced ability to anticipate change, uphold ethical standards, and adapt its governance seamlessly—thereby creating a resilient foundation for the final, market-driven phase of endogenous growth and scale.

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Box 9: 5G+Beidou Integration for Rizhao Port

5G+Beidou Integration Empowers Rizhao Port's Energy Industry to Unleash New-Quality Productive Forces

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Key Challenge: The port needed to ensure the safe and efficient operation of its crude oil terminals and storage areas amid complex environments, including semi-obstructed signals and offshore communication delays.

ICT Solution: Deployment of China's first 5G+low-orbit satellite private network for sea areas, integrated with a Beidou+UWB multi-source fusion algorithm, achieving centimeter-level positioning and real-time data transmission.

Outcomes Breakdown: Increased annual crude oil handling capacity to 8 million tons, reduced unit costs by 15%, and achieved zero crude oil leaks, enhancing both economic and environmental resilience.

Reference Value: This project showcases how advanced ICTs enable predictive maintenance, full-link risk supervision, and data-driven decision-making, refining adaptive governance and building systemic resilience against operational and environmental risks.

▶ 6.6. Phase 5:
Prosperity-Stimulating Endogenous Growth

The final phase of the roadmap represents the culmination of the preceding efforts, aiming to cement digital transformation as a self-sustaining, market-driven force within the SMEs ecosystem. The overarching objective is to stimulate market-driven, value-oriented endogenous motivation for transformation and unlock powerful scale effects. At this stage, digitalization is no longer an external imperative but an intrinsic component of competitive strategy and value creation for SMEs. The strategic focus leverages the fully matured domains of Ecosystem Knowledge Sharing and Innovation Dynamics to create a virtuous cycle where success breeds further innovation and adoption.

This objective is achieved by strategically activating and coordinating the core elements through market mechanisms: Data and Technology become key assets traded in digital markets, Capital flows are directly tied to digital performance via certifications and ratings, and the Ecosystem evolves into a self-reinforcing network of value sharing and collaboration. These efforts are underpinned by Governance & Policy frameworks that ensure fairness and transparency in market operations, while Digital Talent is empowered to drive cultural change and scale success.

This phase is pivotal for transitioning from policy-led initiatives to organic, market-driven growth, where digital advancements are continuously rewarded and scaled. The initiatives create an environment where market forces naturally drive continuous digital advancement, scale effects dramatically lower the cost of innovation for all, and the ecosystem achieves a sustainable state of inclusive growth and resilience.

The logical flow of Phase 5—how targeted initiatives create market incentives, foster value exchange, and scale success to achieve the phase objective—is synthesized in Figure 14.

Figure 14: Phase 5 Strategic Logic—Stimulating Endogenous Growth
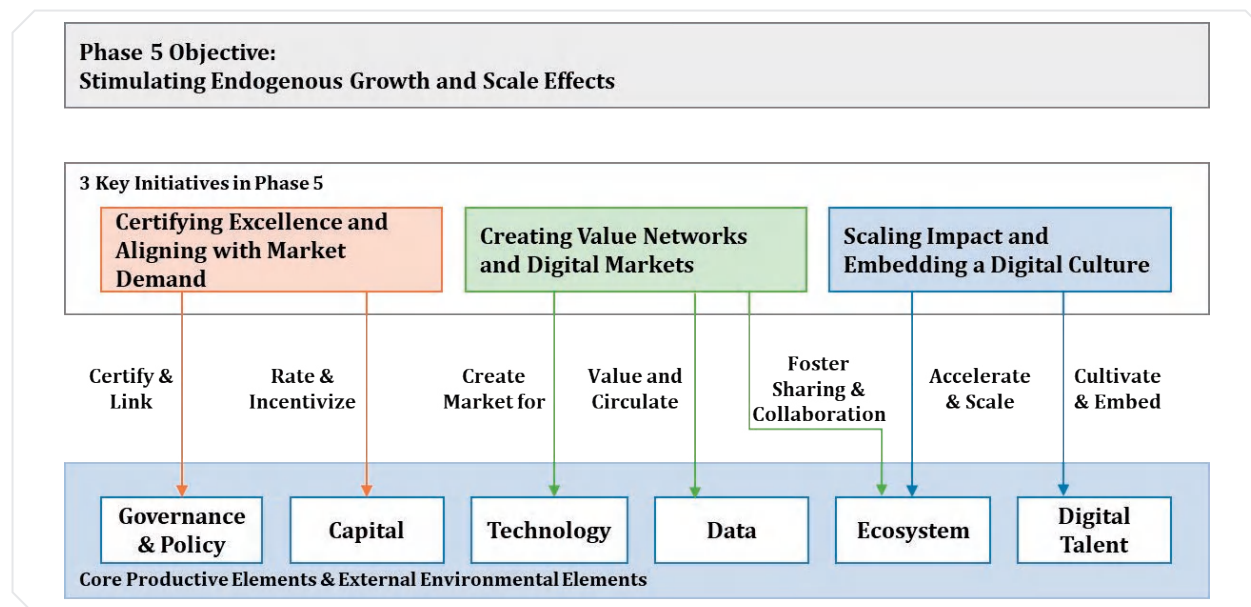
Source: Authors

Key initiatives in this phase are designed to catalyze organic growth, reward digital maturity, and institutionalize a culture of continuous innovation through the following aligned actions:

▶ Certifying Excellence and Aligning with Market Demand

This group of initiatives creates powerful market signals by certifying and rating digital maturity, directly linking excellence to financial incentives and preferential market access. This provides clear economic rewards for continuous improvement and reinforces the business case for deep digitalization.

(1) Establish a "Digital Transformation Benchmark" certification linked to demand: This initiative creates a powerful market signal by certifying SMEs that meet high standards of digital maturity (e.g., in automation, data-driven decision-making). Linking this certification to preferential procurement policies from larger enterprises or government bodies directly translates digital advancement into commercial advantage, providing a clear economic incentive for continuous improvement.

(2) Create a digital supply chain resilience rating linked to financing incentives mechanism: By connecting digital supply chain resilience evaluations with tangible financial benefits (e.g., lower interest rates), this measure rewards SMEs for enhancing transparency and risk management, reinforcing the business case for deep integration and strengthening the entire value chain.

▶ **Creating Value Networks and Digital Markets**

These initiatives establish platforms and alliances that enable SMEs to share, trade, and monetize digital outcomes. They create new revenue streams, validate digital assets as valuable commodities, and foster peer-driven support systems that accelerate ecosystem-wide improvement.

(1) Initiate a "Digital Transformation Alliance" and value-sharing program: This program encourages leading, digitally transformed enterprises to share digital tools, data insights, and even customer resources with allied businesses. This peer-driven support system accelerates improvement across the ecosystem, demonstrating that collaboration can be a source of competitive advantage.

(2) Launch a market-based pricing and trading platform for digital transformation outcomes: This innovative platform allows enterprises to trade standardized products or services derived from their digital transformation, such as surplus computational capacity, proprietary data insights, or even digital methodologies (e.g., selling API call rights). This creates entirely new revenue streams and validates digital assets as valuable commodities.

(3) Support SMEs in building data-driven service models: Provide grants and mentorship to help SMEs use IoT and AI to shift from selling products to delivering "product + service" value (e.g., predictive maintenance offerings). This enables them to participate effectively in the emerging digital markets.

▶ **Scaling Impact and Embedding a Digital Culture**

This set of actions focuses on accelerating the replication of successful models, promoting a cultural shift towards digitalization, and building communities that sustain knowledge sharing and innovation. It ensures that success stories are widely adopted and that a digital-first mindset becomes ingrained in the entrepreneurial community.

(1) Establish a "Scale Effect Accelerator" and cross-border matching program: This initiative identifies highly replicable digital transformation cases and provides targeted support—including branding, international certification, and overseas market channel matching—to help their business models achieve national and global scale, demonstrating the vast potential of successful digitalization.

(1) Establish a "Scale Effect Accelerator" and cross-border matching program: This initiative identifies highly replicable digital transformation cases and provides targeted support—including branding, international certification, and overseas market channel matching—to help their business models achieve national and global scale, demonstrating the vast potential of successful digitalization.

(2) Launch a "National Digital Maker" culture and education campaign: Utilizing media and educational channels to widely promote success stories of individuals and businesses transformed by digital tools is crucial. This final initiative works to shift the pervasive perception of digital transformation from a "cost" to an "opportunity," embedding a digital-first mindset into the cultural fabric of the entrepreneurial community.

(3) Map key industrial chains' digital ecosystem and stakeholder landscape: Provide critical insights into ecosystem structures and stakeholder relationships, identifying opportunities for scaling and replication. This research informs the scaling strategies and helps target interventions effectively.

(4) Cultivate SMEs digital ecosystem communities and knowledge-sharing networks: Establish online and offline communities for SMEs' digital transformation, encouraging businesses to share practical case studies and solutions to common challenges. This peer-to-peer learning sustains momentum and embeds a culture of continuous learning.

Phase 5 signifies the ultimate success of the roadmap: the emergence of a dynamic, self-reinforcing ecosystem. In this stage, SMEs are not merely adopting technology but are actively shaping the digital economy. The initiatives create an environment where market forces naturally drive continuous digital advancement, scale effects dramatically lower the cost of innovation for all, and the ecosystem achieves a sustainable state of inclusive growth and resilience, fully realizing the vision of the Inclusive Digitalization Era.

Box 10: Digital Intelligence-Driven Platform for SMEs Innovation

Digital Intelligence-Driven Innovation Services—Empowerment Solution for Digital Transformation of SMEs

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Key Challenge: SMEs lacked affordable access to advanced digital tools and expertise, facing high barriers to developing data-driven innovation capabilities and accessing growth financing.

ICT Solution: China Mobile's modular, one-stop digital innovation service platform offering selectable AI and data analytics tools via a SaaS model, lowering the technical and cost barriers to entry.

Outcomes Breakdown: Served over 3,000 enterprises, improved production efficiency by an average of 20%, and mobilized ¥1.2 billion in digital transformation project contracts, significantly enhancing SMEs competitiveness.

Reference Value: This case exemplifies an ecosystem approach to innovation capacity building, providing a scalable, low-threshold model for democratizing access to advanced digital tools and fostering data-driven innovation among SMEs.

▶ Reflection: An Integrated Action Roadmap

This section synthesizes the five-phased pathway into a coherent and dynamic integrated action roadmap, designed to guide stakeholders from the current Triple Divide toward the envisioned Inclusive Digitalization Era. The roadmap integrates the temporal logic of the Backcasting Canvas with the strategic domains of the Priority Matrix, providing a holistic view of the journey.
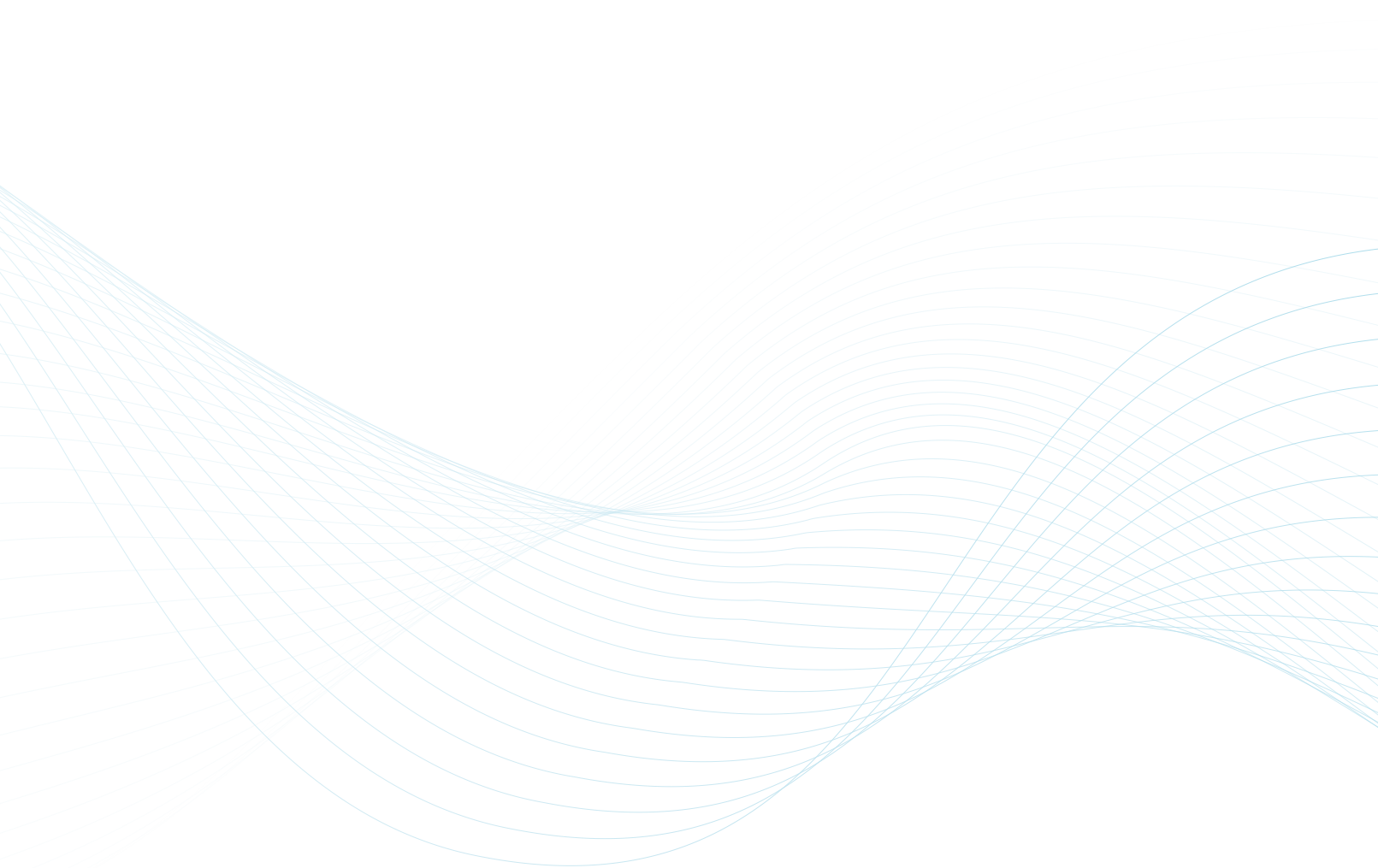
7. MOVING FORWARD

Building upon the detailed roadmap presented in Chapter 6, this concluding chapter addresses the ecosystem-level enablers and imperatives for implementation. It grounds the strategy in reality by examining the internal and external context through a SWOT analysis, highlighting both the leverage points and potential vulnerabilities. Furthermore, it identifies the key actors and their roles via the Stakeholder Engagement Matrix, issuing a clear call to action. The chapter concludes by envisioning the collective achievement of an Inclusive Digitalization Era, emphasizing that its realization hinges on the coordinated and committed efforts of all stakeholders.

▶ 7.1. Navigating the Path Ahead: From Analysis to Action

The SWOT analysis underscores that success hinges on transforming external opportunities into internal capabilities while building resilience against inherent vulnerabilities and external risks. This leads to four core strategic imperatives for the ecosystem:

▶ Leverage Intrinsic Agility to Achieve Technological Promotion
Ecosystem efforts must be designed to amplify SMEs' innate strengths—such as operational autonomy, rapid response capability, and niche expertise. Support mechanisms should be lightweight, modular, and easily integrated, enabling SMEs to quickly experiment with low-cost/high-impact technologies (e.g., AI, SaaS) and capitalize on new data-driven financing models. The focus should be on enabling autonomous innovation rather than imposing rigid, one-size-fits-all solutions.

▶ Bridge Internal Capability Gaps through Targeted Ecosystem Support
The widespread availability of online learning, mature knowledge-sharing platforms, and supportive policies presents an unprecedented opportunity to uplift SMEs capabilities. The ecosystem must provide not just tools, but also the strategic guidance and skills development needed to use them effectively. This includes fostering management's digital vision, enhancing ROI evaluation skills for digital investments, and building interdisciplinary talent through accessible, practice-oriented training and mentorship programs.

▶ **Fortify Defenses against Systemic Risks and Market Volatility**

SMEs' operational autonomy and controllable governance structures are strengths that can be leveraged for risk management. The ecosystem must provide the tools and knowledge for SMEs to defend against cybersecurity threats, navigate complex compliance landscapes, and avoid vendor lock-in. Promoting "security-by-design" and "compliance-by-design" principles, along with affordable shared security services and clear regulatory guidance, is essential to protect SMEs from potentially devastating disruptions.

▶ **Foster Collaborative Advantage to Navigate Intense Competition**

In a future where basic digital tools are ubiquitous, competition will intensify. SMEs' traditional limitations in strategic foresight and resource scale can be overcome through collaboration. The ecosystem should actively foster SMEs clusters, alliances, and knowledge-sharing networks. This allows SMEs to pool resources, share best practices, co-invest in advanced technologies, and collectively negotiate with large platforms, turning individual weaknesses into collective strength.

▶ 7.2. Orchestrating Ecosystem Roles: A Call to Action

The successful digital transformation of SMEs through ICT hinges on a multi-stakeholder ecosystem where each actor plays a distinct yet interconnected role. Mobilizing and aligning these actors based on their influence and engagement attractiveness is critical to activating scalable and sustainable impact.
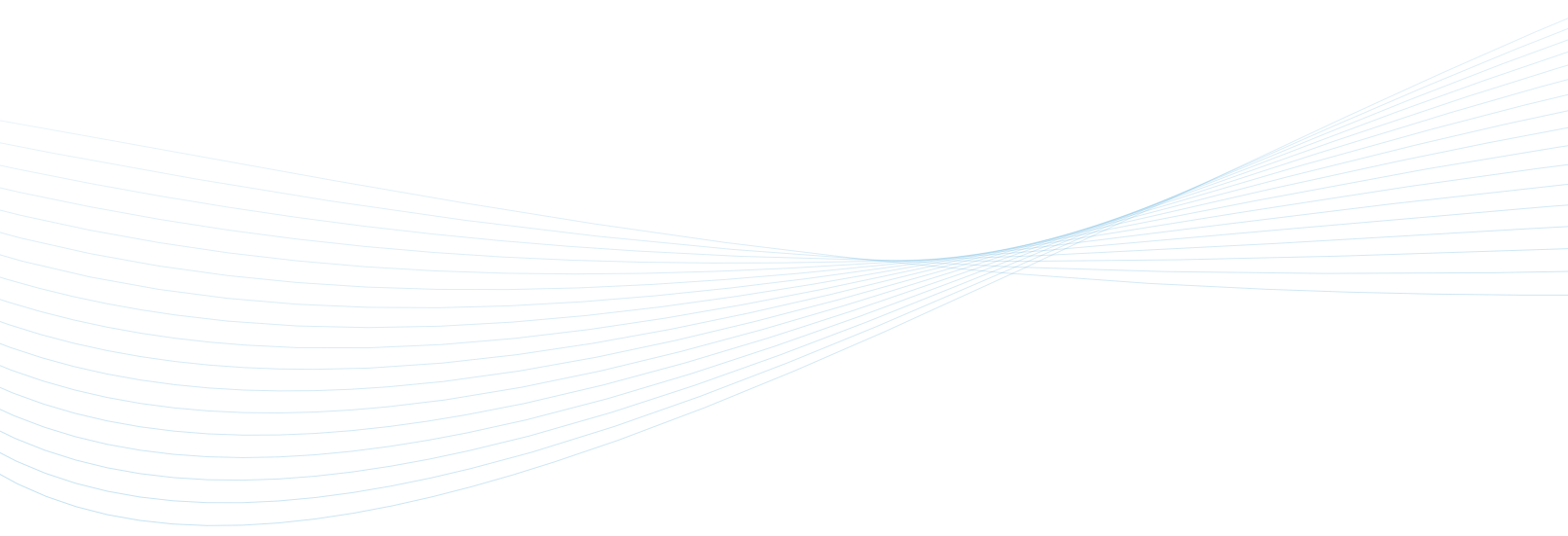
▶ **High-Interest, High-Influence Core Drivers**

A core coalition of highly influential and readily engaged actors should be convened to provide strategic direction, resources, and market access. This group includes:

- **Government Departments:** Key ministries—such as Industry, Finance, Data Governance, Science & Technology, and Commerce—are essential for formulating supportive policies, providing funding, and ensuring regulatory coordination across digital trade, data flows, and innovation.

- **Local Government Bodies:** Local economic development agencies, industrial park management committees, and municipal science and technology departments are pivotal for implementing national strategies on the ground, from ensuring robust digital infrastructure (e.g., 5G coverage) to establishing local digital transformation service centers.

- **Financial Sector Institutions:** A coalition of large commercial banks, policy banks, venture capital firms, and private equity funds is required to provide the spectrum of financing—from credit and grants to equity investments—necessary for SMEs to adopt and integrate ICT solutions.

- **Large Technology and Industry Leading Enterprises:** Multinational and domestic tech giants (e.g., IoT/AI solution providers, cloud service platforms) and dominant firms in various sectors act as key enablers by providing scalable technologies, access to supply chains, and co-innovation opportunities.

- **Standard-Setting and Regulatory Bodies:** Entities like the State Administration for Market Regulation, data protection authorities, and financial regulators should actively participate in creating regulatory sandboxes and compliance frameworks that foster innovation while managing risk.

▶ **Other Strategic Actors for Targeted Engagement**

- **International Organizations & Development Agencies:** Bodies such as the World Bank, OECD, ITU, and regional development banks (e.g., Asian Development Bank) provide crucial international best practices, policy guidelines, and funding for cross-border digital trade projects.

- **Educational Institutions and Platforms:** Universities and online learning platforms are fundamental for developing future-proof digital talent. They could collaborate with industry to create career development centers and tailored training programs that address specific skill gaps in data analytics, cybersecurity, and AI application.

- **Industry Associations and Chambers of Commerce:** National industrial alliances play a vital role in aggregating SMEs needs, organizing knowledge-sharing events, and representing collective interests in policy dialogues and technical standard formulation.

▶ **Foundational Ecosystem Contributors**

The broader ecosystem's health depends on engaged SMEs themselves, startups offering innovative niche solutions, employees eager to upskill, and specialized service providers like legal and consulting firms. Incubators and accelerators support early-stage growth, while insurance institutions and consumer protection groups help mitigate risks and ensure market fairness. While individual SMEs may have lower systemic influence, their collective engagement through associations is the ultimate measure of the ecosystem's success. Similarly, the participation of audit firms, media, and community groups, while less central to strategy setting, contributes essential services for transparency, awareness, and social embeddedness.

No single actor can drive SMEs digital transformation alone. The path forward requires orchestrated collaboration through public-private working groups, co-investment mechanisms, and joint innovation challenges. By clearly defining roles and establishing shared metrics for success, this diverse ecosystem of actors can collectively empower SMEs to harness ICT for enhanced productivity, competitiveness, and inclusive economic growth.

▶ **Envisioning the Destination: Inclusive Digitalization Era**

By embracing these strategic imperatives and fulfilling these roles, stakeholders can collectively steer towards the "Inclusive Digitalization Era". This is not merely a technological upgrade but a fundamental reshaping of the economic landscape. In this future:

- Digitalization is demystified, becoming a standard, manageable feature of business operations for SMEs of all sizes and sectors.
- Innovation is democratized, as SMEs leverage their agility to become prolific sources of niche innovation and job creation.
- Growth is sustainable and inclusive, with digital tools enabling efficient resource use, broader market access, and greater economic participation across regions and social groups.
- The ecosystem is resilient, capable of adapting to shocks and leveraging collective intelligence to navigate future disruptions.

The path forward is complex, but the destination is clear. By moving with purpose, coordination, and a shared commitment to inclusion, we can transform the promise of digitalization into a tangible reality that empowers SMEs to become the enduring engines of global economic vitality.

ANNEX

▶ Annex 1: Abbreviations

AI	Artificial Intelligence
API	Application Programming Interface
AR/VR	Augmented Reality / Virtual Reality
BDT	Telecommunication Development Bureau (ITU)
BIFNC	BRICS Institute of Future Networks, China Branch
CAICT	China Academy of Information and Communications Technology
CCPA	California Consumer Privacy Act
ESG	Environmental, Social, and Governance
ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
ERP	Enterprise Resource Planning
FTTO	Fiber-to-the-Office
F5.5G	Fixed 5.5th Generation (an evolution of F5G)
GDPR	General Data Protection Regulation (EU)
ICT	Information and Communication Technology
ICSB	International Council for Small Business
IFC	International Finance Corporation
IoT	Internet of Things
ITU	International Telecommunication Union
KPI	Key Performance Indicator
MES	Manufacturing Execution System
MSME	Micro, Small and Medium-sized Enterprises
OECD	Organisation for Economic Co-operation and Development
O&M	Operations and Maintenance

PIPL	Personal Information Protection Law (China)
PPP	Public-Private Partnership
R&D	Research and Development
RegTech	Regulatory Technology
SaaS	Software as a Service
SMEs	Small and Medium-sized Enterprise(s)
STEEPLE	Social, Technological, Economic, Environmental, Political, Legal, Ethical (Analysis Framework)
UWB	Ultra-Wideband
VUCA	Volatile, Uncertain, Complex, Ambiguous
5G/6G	Fifth Generation / Sixth Generation (Mobile Network Technology)

▶ Annex 2: References

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Preface of 'ICT-Empowered SMEs Practice Exchange for Digital Transformation'

- Today, emerging ICT technologies—such as AI, cloud computing, industrial internet, and digital twin—are profoundly reshaping the global industrial landscape. They have become a core engine for addressing key challenges faced by SMEs, including high transformation costs, steep technical barriers, and low implementation success rates, while also driving the development of new quality productive forces. Data indicate that SMEs which successfully adopt ICT technologies achieve an average 28% increase in production efficiency and a 40% faster market response speed. Accelerating the integration of ICT technologies across the entire workflow of SMEs—from R&D and production to management—has become an essential pathway for achieving high-quality development among SMEs worldwide.

- To identify replicable and implementable transformation practices, under the guidance of the International Telecommunication Union (ITU), the China Academy of Information and Communications Technology (CAICT), in collaboration with the China Branch of BRICS Institute of Future Networks (BIFNC), launched a global call for exemplary practices on "ICT-Enabled Digital Transformation for SMEs" in September 2025. The initiative received enthusiastic responses from SMEs and ICT technology service providers. After reviewing 20 valid submissions, the "Practice Exchange on ICT-Enabled Digital Transformation for SMEs (2025)" has been compiled.

- The selected practices focus on the practical application of ICT technologies across the entire value chain of SMEs, offering substantial practical reference value. They specifically cover six key areas:

1. Digital Integration Support for SMEs »

Solutions featuring systematic deployment and integrated application of ICT technologies such as cloud computing, big data, and IoT in SMEs.

2. Customer Experience & Market Innovation »

Solutions where ICT technologies like cloud computing, big data, and IoT enhance customer experience and drive precision marketing for SMEs.

3. Manufacturing & Operational Efficiency Enhancement »

Solutions where ICT technologies such as industrial internet and digital twin improve manufacturing and operational efficiency for SMEs.

4. Product/Service Innovation »

Solutions leveraging ICT technologies to facilitate product or service innovation in SMEs, including digital product design, data-driven product iteration, and other typical enabling cases with significant replicability.

5. AI-Powered Innovation »

Solutions applying AI technology in core business scenarios of SMEs, including intelligent management, intelligent operations, and other typical enabling cases with significant replicability.

6. Other Emerging Technology Application »

Solutions involving the integrated application of other cutting-edge ICT technologies.

- This collection serves not only as a "compendium of practical experiences" for the global digital transformation of SMEs, but also strives to provide "actionable, replicable, and implementable" transformation pathways for SMEs across different regions and industries.
- The coming period represents both a "critical phase" and a "window of opportunity" for the digital transformation of SMEs worldwide. Through this collection, we aim to enable ICT technologies to truly become a "catalyst" for SMEs to bridge the digital divide and harness new quality productive forces. Should any inaccuracies or omissions be found within this publication, we welcome your feedback.

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2025

Chapter 1: Digital Integration Support for SMEs

CHAPTER OVERVIEW

- SMEs worldwide are accelerating comprehensive digital restructuring, with the core objective of breaking down departmental silos, achieving cross-department and cross-system data integration and sharing, and enabling end-to-end business collaboration. ICT technologies are becoming pivotal in linking the entire chain—from R&D, supply chain, and production to marketing, services, and finance. Cloud-native architecture, low-code platforms, digital twin, IoT sensing, and AI-driven decision-making are deeply embedded across various scenarios. For instance: In R&D and design, low-code collaborative platforms enable geographically dispersed teams to co-create digital prototypes in real time using R&D design software, while digital twin technology ensures real-time synchronization of "R&D parameters and production processes." In supply chain management, IoT and big data build visible tracking systems capable of dynamically forecasting raw material demand and monitoring logistics nodes. In financial management, cloud accounting platforms integrate operational data to automatically generate financial reports and provide early warnings for fund-related risks. These technological applications not only enhance efficiency in individual segments but also drive data fluency across the entire process, enabling a closed loop from "digitizing business operations" to "operationalizing data." This marks a transition for SMEs from "fragmented digitalization" toward "full-chain intelligence."

- SMEs in developing countries face more complex challenges in implementing end-to-end digitalization than in single-process transformation: First, disjointed process coordination. Most SMEs grapple with "system silos" – standalone tools like CAD for R&D, MES for production, and CRM for sales operate independently. Lack of interoperability across platforms hinders data exchange, leading to delays in decision-making across the entire workflow. Second, rising cost pressures. End-to-end digitalization requires integrating multiple systems, with expenses related to hardware and software procurement, customization, and maintenance often exceeding SMEs' reasonable cost tolerance. Third, heightened data security risks. End-to-end processes involve core R&D data, customer privacy information, and sensitive financial data, yet SMEs frequently lack dedicated

cybersecurity teams. Fourth, skills mismatch. Comprehensive digital transformation demands employees master cross-functional tools – for instance, R&D staff needing data analysis skills, or sales personnel required to use supply chain alert systems. However, proficiency in cross-functional digital skills remains relatively low among employees in SMEs across developing countries. Fifth, system integration difficulties. Traditional SMEs often rely on on-premises systems, and integrating these with cloud-native, end-to-end platforms incurs additional adaptation costs. Some firms abandon full-process digitalization due to these integration challenges.

• Addressing the aforementioned challenges, the four typical practices featured in this chapter focus on solutions centered around "lightweight integration + low-code empowerment + ecosystem collaboration." For instance, JOYVIO Group's "Lightweight ICT Service Package" enables end-to-end digital transformation for agricultural SMEs. Its core approach combines a "lightweight ICT service package" with "full-process accompaniment," establishing a "data foundation + modular application" technical architecture to lower the barriers for agricultural SMEs. Shenzhen Transmi Technology Co., Ltd.'s "Digital Work Full-Process Management Platform" utilizes five modules—demand planning and design, IT project costing, full-process project approval, project implementation management, and code cloud hosting—to achieve end-to-end visibility, control, and management of digital project development. Shenzhen High-Tech Industrial Park Information Network Co., Ltd. helped Zanty Electronics build the foundation for a transparent factory through "production equipment data collection and networking." By collecting data from each piece of equipment, connecting the factory's production equipment (i.e., Industrial IoT, IIoT), and uploading data to an IoT platform, they achieved full-process optimization of Zanty Electronics' production and operations. Shanghai Jiao Tong University School of Medicine has established a next-generation campus network covering eight major scenarios, including smart classrooms, clinical training, and smart laboratories. The network architecture features a simplified design, high bandwidth, intelligent operations, and scalable evolution, effectively addressing the university's needs for high data concurrency and flexible network configuration in teaching and research activities.

• These practices demonstrate that through lightweight technology integration and low-code platforms that lower the application threshold, the challenges of "fragmentation, high costs, and high risks" in SMEs' end-to-end digitalization can be effectively addressed, building a sustainable, intelligent, full-chain operational ecosystem.

Joyvio Group's "Lightweight ICT Service Package" Empowers the Whole-Process Digital Transformation of SMEs in Agriculture

PRACTICE PROFILE

Addressing common challenges faced by SMEs in agriculture—such as reliance on experiential planting, lack of field operation records, difficulties in coordinating harvesting and sales, low standardization in processing, lengthy cold chain logistics cycles, and data-deficient marketing strategies—Joyvio Group has developed a replicable ICT-based solution.

This initiative provides digital transformation services to over 50% of small and medium-sized agricultural enterprises across the fruit industry chain, spanning planting, processing, and distribution.

Focusing on 3 core areas—farming operations, production and processing, and supply chain and marketing collaboration—the solution is implemented over a 1-2 year period. It helps enterprises achieve an average 18% increase in production efficiency, a 25% improvement in supply chain responsiveness, and a 30% enhancement in marketing precision.

The package is readily adaptable to various agricultural sectors, offering a universal reference for the digital transformation of SMEs in agriculture.

DETAILED DESCRIPTION

Solution Implementation Details »

"Data Foundation + Modular Applications": Layered Architecture Lowers the Barrier to Digital Transformation for SMEs in Agriculture

Joyvio Group adopts a core approach of "Lightweight ICT Service Package + Full-Process Support" to build a "Data Foundation + Modular Applications" technical architecture, reducing the barriers for agricultural SMEs in their digital transformation.

The architecture is divided into 3 layers:

- The bottom layer relies on cloud servers to establish a data storage and computing foundation, compatible with enterprises' existing hardware.
- The middle layer develops on-demand selectable ICT modules, such as production monitoring, supply chain collaboration, and marketing analysis.
- The top layer integrates data and provides decision-making support through visual dashboards.

The project deploys an ICT technical team of 10 members (including 5 dedicated agricultural digitalization consultants) and offers standardized hardware rental services such as sensors, robots, and smart terminals.

Data sources integrate enterprise production data, publicly available industry data, and third-party meteorological and market data. Throughout the process, technical training and operational support are provided to ensure the solution is scalable and implementable.

Outcomes Breakdown »

In terms of economic benefits, end-to-end digital intelligence drives cost reduction and efficiency improvement across production, processing, and distribution. Taking the blueberry industry as an example, the planting segment achieves a yield of 30 tons per hectare with an economic benefit of RMB 450,000 - 750,000 per hectare.

Through a digital management system, the following improvements have been realized:

- Labor scheduling efficiency has increased by 40%,
- Production efficiency by 15%,
- The rate of premium fruits has risen from 65% to 82%,
- Distribution loss has decreased from 25% to 12%.

The regional brand premium for blueberries in mountain areas in Yunnan reaches 20%. After cross-regional replication of this solution, the sorting efficiency of pineapples in Hainan improved by 30%, and the compound fertilizer usage for honey pomelos in Fujian was reduced by 60%.

Regarding social benefits, the initiative aligns with the SDGs:

- **Contributing to Goal 1 (No Poverty):** It supports over 30 villages in Yunnan's production areas and provides employment for around 200,000 farmers, increasing per capita annual income by RMB 30,000–40,000.
- **Addressing Goal 12 (Responsible Consumption and Production):** The smart water and fertilizer system saves 35%–50% in water usage and 30%–40% in fertilizer consumption.
- **Supporting Goal 8 (Decent Work and Economic Growth):** It offers annual agricultural technical training for 1,000 participants, enhances the digital literacy of new farmers, shortens vocational skill acquisition from 6 months to 2 months, and introduces a multilingual system to overcome language barriers among ethnic minorities, promoting ethnic unity and employment equity.

Value Proposition »

"Multi-Sector Adaptability + Low Barriers & Quick Returns: Delivering Implementable and Adaptable Solutions for Global Agricultural Digitalization"

Designed to address common pain points across the agricultural industry chain, this solution demonstrates strong generalization capability. It has been successfully replicated from blueberries to fruits such as pineapples and honey pomelos, and further extended to animal husbandry and group catering services—all without large-scale restructuring.

With low resource thresholds, hardware deployment (including sensors and other devices) can be configured as needed. On the software side, the agri-food industry is deconstructed into five industry chains and scenarios, with corresponding models built through digital intelligence technologies. Any agricultural region or enterprise can avoid an "all-in-one" transformation; instead, they start by establishing a foundation and one of the most critical modules, then gradually expand—enabling lightweight, flexible, and efficient modular deployment.

Execution is supported by professional consulting and implementation teams that not only provide product solutions but also offer consulting and fast, convenient digital services, reducing the barrier to enterprise transformation by 50%. Skill requirements are tailored to agricultural practitioners—basic training is sufficient for operation, and the skill acquisition cycle for new employees is shortened from 6 months to 2 months.

The payback period for transformation is short: efficiency gains and cost reductions from end-to-end digital intelligence quickly cover the initial investment. With open data interfaces and a sharing platform, partner organizations achieve an average annual revenue growth of 62.8%. The solution holds strong potential for international promotion, offering a practical and adaptable model for global agricultural digitalization.

IMPLEMENTING ENTITY PROFILE

Joyvio Group Co., Ltd. »

Entity Type   Private sector

Core Business »

Joyvio Group is a pioneer in modern agricultural and food industrialization. Established in 2012, the company is committed to building a global digital platform spanning multiple industries. Through end-to-end digital transformation and innovative models, it drives the modernization of the global agri-food sector and promotes improvements in public nutrition.

Digital Full-Process Work Management Platform

PRACTICE PROFILE

Under the momentum of emerging technologies, small and medium-sized enterprises (SMEs) are accelerating their digital transformation. However, the key to success lies not in the sophistication of technology itself. Common challenges during projects include redundant project approvals, fragmented oversight, inaccurate cost estimations and project scopes, and difficulties in knowledge retention and reuse. Therefore, it is essential to tailor solutions to the enterprise's actual context and ensure cross-departmental collaboration throughout the implementation.

The full-process digital management platform addresses these issues by comprehensively overseeing project approval, planning, design, construction, and operations & maintenance. This end-to-end control ensures efficient workflows, reduces risks, and enhances transformation success rates. By integrating data resources and optimizing resource allocation to minimize waste, the platform enables agile business responsiveness. Through strengthened internal coordination and continuous optimization mechanisms, it empowers SMEs to achieve successful digital transformation, laying a sustainable foundation for competitiveness.

DETAILED DESCRIPTION

Solution Implementation Details »

Digital Project Full-Process Management Platform

This integrated platform resolves challenges in project coordination and implementation through one-stop solutions.

End-to-End Project Approval

Manages the entire project lifecycle (planning → execution → monitoring → closure) with standardized, transparent, and efficient approval workflows. Enables holistic oversight and centralized control.

Demand Planning & Design

Integrates requirements gathering workflows, data traceability, and design accountability. Ensures alignment with user needs during planning/design phases, boosting delivery success rates (+27% industry average) and user satisfaction.

Project Implementation Management

Coordinates requirement tracking, implementation plans, progress monitoring, defect management, and risk mitigation. Enhances team collaboration, execution efficiency (+40% reported), and on-time quality delivery through real-time oversight.

IT Project Cost Engineering

Leverages historical functional inventories, cost guidelines, simulation tools, and auditing mechanisms. Maintains budgetary control (±5% variance) while improving ROI through data-driven cost optimization.

Cloud Code Hosting

Unifies source code management via version control, repository administration, quality gates, and managed services. Ensures immediate access to validated, executable code versions, accelerating development velocity and reducing defects by 30%.

The Digital Project Whole-Process Management Platform achieves full visibility, control, and management throughout digital project development through five modules: requirements planning and design, information engineering cost management, project-wide process approval, project implementation management, and cloud code hosting. The diagram illustrates the complete project development cycle, including:
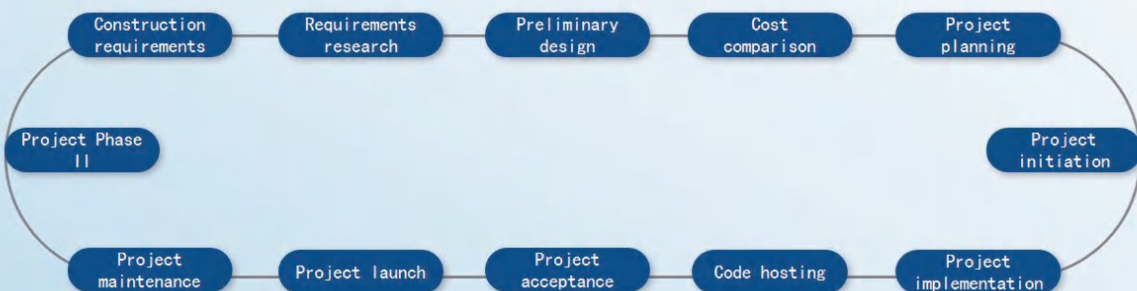
Outcomes Breakdown »

TheDigital Work Whole-Process Management Platformintegrates resource intensification and process standardization via a dual-track synergy mechanism to eliminate project redundancies, reduce initial costs, and minimize resource waste through end-to-end oversight (planning/approval/construction). It compresses rework expenses via precision research and collaborative design while lowering operational costs through full lifecycle source code management. The platform further enhances capital efficiency with quotation and workload assessment benchmarks, strengthens cross-project/stakeholder coordination for collaborative effectiveness, and elevates public trust via transparent supervision. Data visualization enables scientific decision-making, standardization ensures public service quality, and collectively drives maximized investment returns alongside holistic service equilibrium optimization.

Economic Benefit Quantitative Assessment

Benefit Points	Outcomes
Avoiding Redundant Construction	Initial investment decreased by 12-15%
Whole-process Supervision Reducing Waste	Resource consumption rate less than 7.2%
Precise Research Reducing Rework	Rework cost decreased by 23%
Source Code Management Reducing Maintenance Cost	Operation and maintenance cost decreased by 30%
Quotation Reference Improving Capital Efficiency	Budget deviation within ±3.5%

Social Benefit Intensity Evaluation

Benefit Points	Outcomes
Overall Management Enhancing Collaboration	Synergy efficiency increased by 40%
Whole-process Transparent Supervision	Compliance pass rate reached 98%
Data Supporting Scientific Decision-Making	Decision-making speed increased by 35%
Design and Construction Synergy	Acceptance pass rate reached 95%

Value Proposition »

The Digital Work Whole-Process Management Platform employs modular design (e.g., microservices architecture, standardized data interfaces) to enable rapid cross-regional deployment. Its low-code configuration capability and preconfigured industry templates significantly lower technical adaptation barriers, allowing resource-scarce regions to directly reuse core functions and avoid redundant investments. Concurrently, the platform supports remote-area operations through lightweight terminals (e.g., mobile apps) with offline functionality, while multilingual interfaces and accessibility design ensure coverage for diverse user groups. By consolidating fragmented resources through data collaboration, it enables traditional SMEs to achieve quality and efficiency gains from digitalization. Furthermore, the platform accelerates green technology adoption via transparent supply chain management, reduces transformation costs for small businesses, and eliminates participation barriers from information asymmetry through collaborative governance mechanisms. This creates a closed loop of replicability, digital inclusivity, and multidimensional alignment, ultimately driving mutual reinforcement between technology democratization and sustainable development.

IMPLEMENTING ENTITY PROFILE

Shenzhen Chuangshi Hulan Technology Co., Ltd. »

Entity Type   Startups and SMEs

Core Business »

Committed to building full-stack information and digital scenario solutions, the enterprise focuses squarely on digital transformation and upgrading. Leveraging its comprehensive capabilities in full lifecycle management for software development, it delivers end-to-end digital enablement to businesses.

Data collection and networking of production equipment lays the foundation for Zong Tai Electric to establish a transparent factory.

PRACTICE PROFILE

Zongtai Motor, founded in 2014, is a national high-tech enterprise, a "specialized, refined, characteristic, and innovative" small and medium-sized enterprise in Shenzhen, and an Engineering Technology Research Center for High-Reliability Intelligent Control Fluid Solenoid Valves certified by the Department of Science and Technology of Guangdong Province. For a long time, it has been facing the following problems:

1.Difficult equipment management: Currently, there are 51 injection molding machines and machining equipment in multiple workshops of one factory in the park. There are 4 brands and models of injection molding machines, and 5 brands and models of machining equipment. The equipment varies from new to old, with a large span of service time. The company's equipment management, spot checks, and other work still remain in the paper-based era.

2.Inability to directly control the production site: The company's equipment cannot be directly connected to the network, so it is impossible to obtain information about the production site in real time. Engineers are exhausted from running back and forth, dealing with various issues related to processes, quality, work orders, and production lines every day.

In July 2025, China Telecom and Shenzhen High-Tech Zone Information Network, together with Shenzhen Laogou Technology Co., Ltd., carried out data acquisition for each piece of production equipment, connected the factory's production equipment to the network (i.e., Industrial Internet of Things, IIoT), and uploaded the data to the IoT platform. This unreservedly presented the "mysterious data" hidden under each device to the company's management and engineers, thereby realizing the optimization of the entire production and operation process of Zongtai Motor.

PRACTICE PROFILE

This project will not only accelerate the digital and intelligent upgrading of Zongtai Motor, improve production efficiency and management level, and bring Zongtai Motor's intelligent upgrading strategy into a substantive implementation stage, but also strive to build an industry benchmark for smart factories and provide replicable successful experience for the digital transformation of the industry.

DETAILED DESCRIPTION

Solution Implementation Details »

Digital transformation measures focused on improving production efficiency and equipment utilization effectiveness (OEE)

China Telecom and Gao Xin Network have carried out digital transformation of their primary production equipment. The specific measures and plans include:

- **Full-scale equipment access:** Using various methods such as serial port communication acquisition, network port communication acquisition, IO acquisition, database acquisition, and logfile parsing to obtain data from CNC machines, machine tools, injection molding machines, lathes, and other production and processing equipment operated by Zong Tai Electric.

- **Statistical analysis:** Employing sophisticated data statistical analysis and mathematical formula calculations to achieve bidirectional interaction between data acquisition and writing, enabling production statistics, downtime statistics, defect statistics, and other dimension data communication analysis.

Reports or electronic dashboards are then generated for output. Through this implementation, the mysterious data hidden beneath each piece of equipment has been brought to light before the eyes of the company's management and engineers. This has enabled Zong Tai Electric's management to address critical issues in production operations, improve production efficiency, quality, and decision-making capabilities, and provide the necessary support for these improvements.

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中国电信 中国电信股份有限公司深圳分公司

MODEL NO: SupBOX-DKM-2LAN
POWER: DC 24V （AT） CE
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Data interaction	MES	Equipment management software	ERP
application software	Industrial APP	Cockpit	Electronic signage	Reporting management	DNC management
Data processing	Data cleaning		Data caching/storage		data analysis

- Equipment data
- Production process data

Communication data acquisition/IO data acquisition

MES/ERP/Equipment Management Software SERVER

Production data, equipment data

local server

Edge computing gateway

Wi-Fi

Industrial Ethernet

Outcomes Breakdown »

Specific benefits and values include:

1.Realized real-time monitoring and transparent production.

By obtaining real-time data on equipment operating status (such as startup/shutdown, temperature, pressure, vibration and other parameters) and production progress, the "black box" in production is eliminated, and plan deviations caused by information lag are avoided

2.Achieved predictive maintenance and equipment health management.

Real-time monitoring of equipment health indicators (such as current, vibration, energy consumption) enables prediction of potential failures. This helps customers shift from reactive maintenance to predictive maintenance, reducing unplanned downtime, extending equipment lifespan, and lowering maintenance costs.

3.Achieved quality traceability and process optimization.

Each real-time data collection records processing parameters (such as dimensional accuracy, temperature curve) and quality inspection results, which are associated with production batches. This enables Zongtai Motor to quickly locate the root causes of quality issues (e.g., process parameter deviations) and improve product qualification rates.

4.Achieved resource scheduling and cost control.

The data collected this time also includes information on equipment utilization, energy consumption, and material consumption. This provides decision support for customers to optimize production rhythm and resource allocation, identify production bottlenecks, and reduce energy and raw material waste.

5.Achieved data-driven decision-making and system integration.

Through the information display on the BI big screen, the data barriers between equipment, MES, and ERP are broken down, forming a unified analysis platform. This avoids information silos and improves cross-departmental collaboration efficiency.

The ultimate goal of equipment data acquisition is to achieve intelligent manufacturing through a data closed loop (acquisition → analysis → optimization). For Zongtai Motor, the implementation of this data acquisition project can reduce its equipment failures by 30%-40% and increase its production efficiency by more than 20%.

Value Proposition »

Zong Tai Motor's "lightweight" equipment data collection retrofit serves as a low-cost digital transformation model for small and medium-sized manufacturing enterprises.

The equipment data collection and transformation project implemented by Zong Tai Motor recently has successfully upgraded old production equipment through the introduction of a low-cost, highly compatible data acquisition solution. This approach avoids the heavy burden of scrapping a large number of outdated equipment, providing enterprises with a pragmatic and efficient digital transformation path. The experience gained from this project holds significant reference and promotion value for manufacturing enterprises.

The value of this project includes: improving production efficiency and equipment utilization (OEE), enabling predictive maintenance, enhancing product quality and consistency, optimizing energy consumption and costs, strengthening production visibility and decision support, boosting supply chain collaboration and flexibility, improving the working environment and safety, and supporting product and service innovation.

The core value of connecting production equipment to the network lies in transforming the operation of physical equipment into measurable, analyzable, and optimizable digital information flows. This brings enterprises unprecedented transparency, control, insight, and agility, which ultimately translate into higher production efficiency, lower production costs, better product quality, stronger market competitiveness, and innovative business models. Although the implementation process involves investment and technical challenges (such as cybersecurity, data integration, and protocol compatibility), the long-term benefits it brings are enormous, and it is an irreversible trend in the digital transformation of the manufacturing industry.

IMPLEMENTING ENTITY PROFILE

Shenzhen High-tech Zone Information Network Co., Ltd. »

Entity Type — High-tech enterprises, technology-based small and medium-sized enterprises

Core Business »

Shenzhen High-Tech Zone Information Network Co., Ltd. (a member of China Telecom Group and a national high-tech enterprise) relies on 5G private networks, industrial internet platforms, and AIoT technology to provide manufacturing enterprises with full-chain digital services such as smart factory data acquisition (millisecond-level latency transmission), AI quality inspection, predictive maintenance, and flexible production management.

The company has R&D capabilities certified by CMMI-DEV V2.0 ML5, independently developed three core systems including the IoT sensing platform and the smart government affairs information platform, and has in-depth cooperation with Fortune 500 enterprises such as Huawei and ZTE. It has helped customers in industries such as shipbuilding and steel achieve practical results of a 40% increase in production efficiency and a 30% decrease in defect rates.

10G All-Optical Network Promotes High-Quality Development of Digital and Intelligent Campuses

PRACTICE PROFILE

Shanghai Jiao Tong University School of Medicine is one of the first ten key universities jointly established by the Ministry of Health and the Ministry of Education. Currently, it has 11,117 students enrolled, including 3,790 undergraduates, 7,181 graduate students, and 146 international students. The campus network is a crucial component of the university's "Digital and Intelligent Campus" information infrastructure. With the application of AI technologies such as gene sequencing, intelligent analysis of pathological images, and naked-eye 3D anatomy teaching, the traditional network could no longer meet the needs of simultaneous use by both teachers and students. To address these technical challenges, the project team conducted multiple evaluations and ultimately chose the F5G-A 10Gbps all-optical network, which offers 99.999% reliability. They built eight major scenario-based networks, including smart classrooms, clinical training rooms, and intelligent laboratories. This network features simplified architecture, high bandwidth, intelligent operation, and easy evolution, effectively meeting the university's requirements for concurrent data processing and flexible networking in teaching and research.

DETAILED DESCRIPTION

Solution Implementation Details »

All-Optical Network Solves AI Challenges for Schools

Shanghai Jiao Tong University School of Medicine hope to build a "digital and intelligent campus" with distinctive features of medical education. The project has deployed a total of 8 OLTs and 4,024 ONUs.

From the overall network topology perspective, the Pudong and Huangpu campuses are directly connected via 10G bare optical cables. The core networks of both campuses are connected to their respective data centers to achieve disaster recovery and backup. In addition, the campus networks are also connected to the main campus of Shanghai Jiao Tong University, the Education and Research Network, and the telecom network.

At the Pudong campus, OLT devices are connected to ONUs and APs in teaching areas, office areas, and dormitory areas through optical splitters, ensuring a stable, efficient, and secure network architecture. The project team has designed the campus network based on specific scenarios, configuring all-optical devices according to the needs and characteristics of different scenarios. For example, in smart laboratories, which require extremely high bandwidth, stability, and security, the gene sequencers need to be connected to 10G ONUs to work with AI computing power for rapid data analysis. Important applications such as AGVs (Automated Guided Vehicles) are given priority protection through dedicated network services. IoT devices no need separate networks, they can all be carried on a single optical network, reducing network construction costs and maintenance complexity.
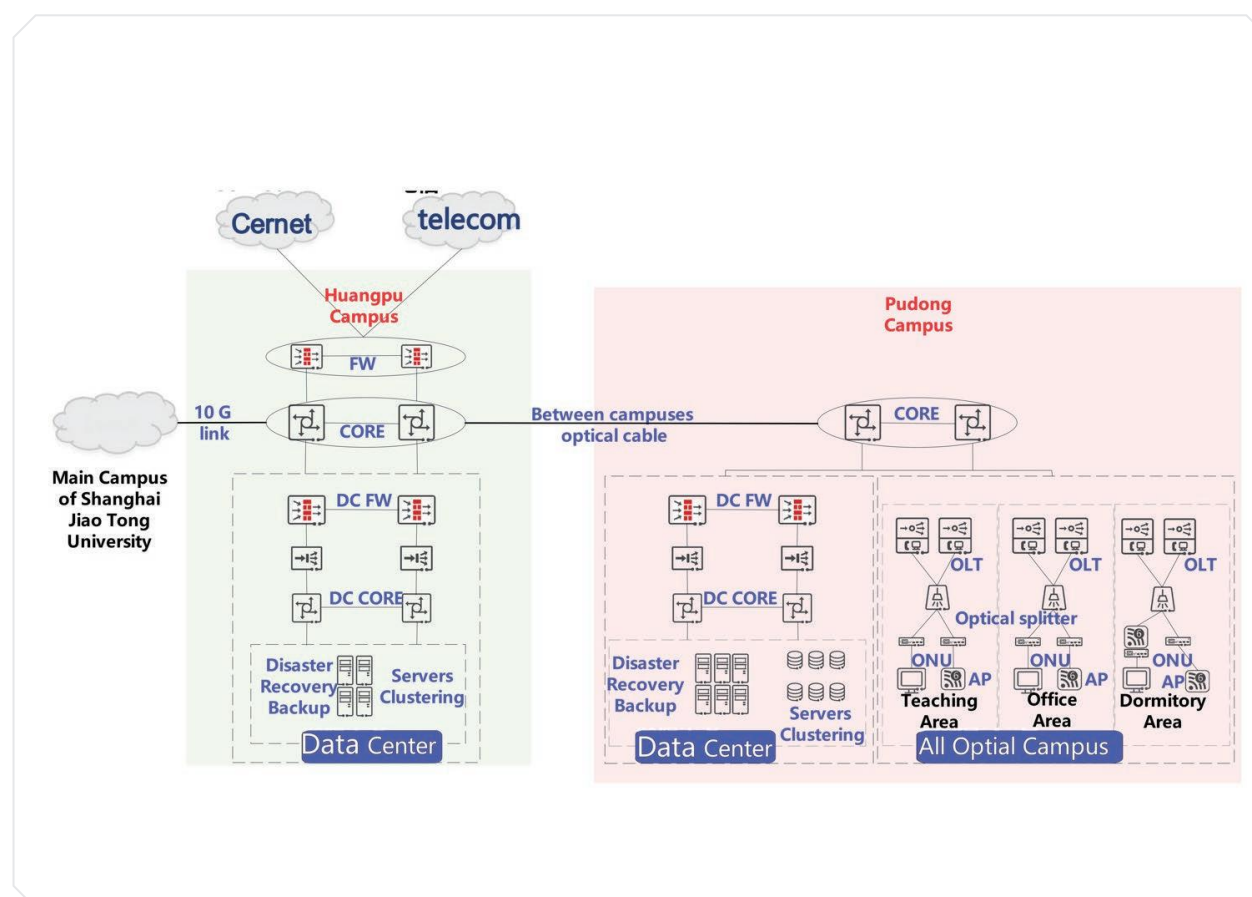
Outcomes Breakdown »

Integrating Multiple Networks, Enhance Teaching and Research Capabilities:
The School of Medicine at Shanghai Jiao Tong University adopted the F5G-A 10G all-optical network solution to integrate multiple dedicated networks, including security, examination, finance, campus card, and multimedia systems. This integration reduced costs by more than 20%, while upgrading the network from gigabit to 10 gigabit, increasing bandwidth by ten times. This advancement supports "AI + Medicine" and helps overcome technical challenges.

Simplified Architecture, Enhanced Campus Network Reliability:
The fiber-based Layer 2 architecture reduces cable weight and space usage by 90% compared to traditional copper cables. Passive optical splitters do not occupy equipment room space, and there is no risk of fire in the ELV room, saving space and facilitating future network expansion. In addition, the OLT and link redundancy design improves reliability to 99.999%, meeting the AI research requirements.

Environmental Protection, Continuous Evolution of All-Optical Technology:
Compared to copper cables, optical fibers use environmentally friendly quartz glass, which is lighter in weight, allows for longer data transmission distances, and provides higher bandwidth. The network can smoothly upgrade from 10G PON to 50G PON without replacing the optical fibers. By replacing a large number of traditional copper cables with all-optical networks, the campus network saves 90% of metal resources. On average, a campus saves about 1.2 tons of metal. In addition, the lifespan of optical fibers is three times that of copper cables, allowing them to witness the development of the university alongside the campus buildings.

Value Proposition »

- Traditional campus networks have numerous information access points, with dozens of ELV rooms. Most of these rooms are fully occupied by equipment, leaving no room for expansion. The access rate is generally 100 Mbps. During peak hours, traffic is highly concentrated, leading to severe data lag. As digital upgrades in scientific research and teaching increase, the number of intelligent terminals continues to grow, and the outdated network infrastructure can no longer support these demands.

Value Proposition »

• In this case, the all-optical network design for eight typical scenarios, including smart classrooms, digital libraries, and smart laboratories, provides 10 Gbps access for scientific research and zero-wait AI data processing. In ELV rooms, the equipment is passive and poses no fire hazards. In libraries, the equipment operates silently, not disturbing the learning environment. In outdoor and other scenarios, the optical fibers are corrosion-resistant and can last for 30 years. The advantages of an all-optical campus network can serve as a reference for intelligent network construction in higher education institutions.

• The integration of F5G-A 10 Gbps all-optical campus networks with AI applications not only meets the requirements for network coverage in various scenarios but also enhances user experience, improving management efficiency by 60%. The devices are plug-and-play, requiring minimal technical skills from personnel. At the same time, the overall cost is reduced by 20%, and the data rate is increased by 10 times, meeting the needs of campus networks and teaching and research activities in the education industry.

IMPLEMENTING ENTITY PROFILE

Shanghai Jiao Tong University School of Medicine »

Entity Type Academia/Research Institution
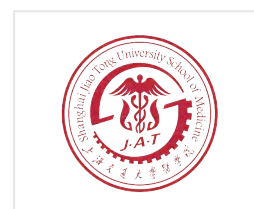
Core Business »

In July 2005, Shanghai Jiao Tong University merged with Shanghai Second Medical University to establish a new Shanghai Jiao Tong University School of Medicine, jointly supported by the Ministry of Education and the Shanghai Municipal Government. The university comprises 25 colleges (departments) and 13 affiliated hospitals.

CUSTOMER EXPERIENCE & MARKET INNOVATION

02
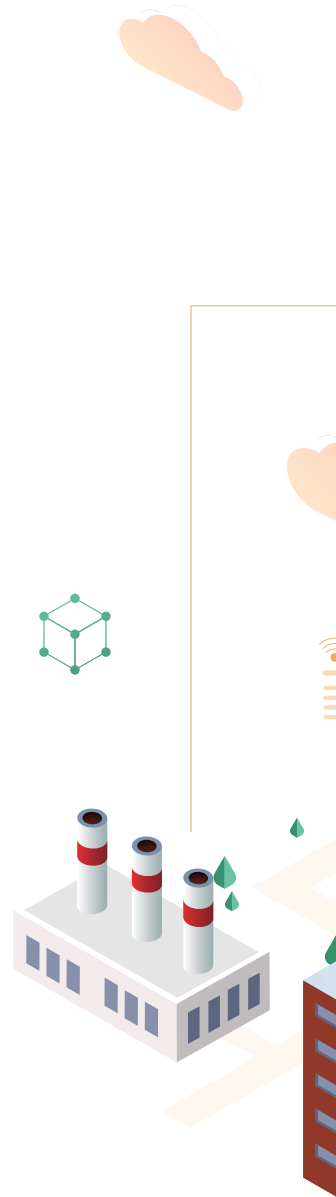
Chapter 2: Customer Experience & Market Innovation

CHAPTER OVERVIEW

- SMEs worldwide are accelerating their shift from "broad-reach marketing" to "precision targeting + experience value-add," with ICT technologies serving as the core enabler for integrating the "user insight → contextual engagement → experience optimization → repurchase conversion" chain. Technologies such as user profiling engines, omnichannel experience management, personalized recommendation algorithms, and marketing attribution analysis are deeply embedded across marketing and service scenarios: In user insight, AI-powered multi-source data integration tools (combining data from e-commerce platforms, social media, and physical stores) build a 360° user tagging system. In contextual engagement, omnichannel marketing systems seamlessly connect "social media influencer marketing → mini-program try-on → in-store pickup → community-based after-sales." In experience optimization, AR/VR technologies enable immersive experiences (e.g., AR virtual makeup trials, VR furniture previews), complemented by intelligent customer service bots (24/7 response with one-click after-sales issue tracing). In conversion and repurchase, marketing attribution models (multi-touch attribution algorithms) identify key conversion paths, while personalized recommendation engines push relevant products in real time based on user behavior. These applications not only enable "precision customer targeting" but also foster user loyalty through optimized full-touchpoint experiences—signaling the evolution of SME marketing from "traffic-driven" to "dual-driven by experience and data."

- SMEs in developing countries face more complex practical obstacles in Customer Experience & Market Innovation transformation than mere technical application: First, weak data foundations. SMEs in developing countries often only collect basic e-commerce platform data (such as orders and browsing history), lacking critical data from social media interactions and offline in-store behaviors, resulting in fragmented user profiles. Second, high technical barriers and costs. Specialized systems like personalized recommendation algorithms and AR experience tools entail high customization costs, and SMEs lack the marketing technology talents capable of operating such systems. Third, disjointed omnichannel experiences. Online sales rely on third-party e-commerce platforms while offline operations depend on manual

record-keeping, with no data interoperability between systems. Fourth, difficulty in measuring marketing effectiveness. SMEs in developing countries still use superficial metrics like "click-through rates and impressions" to evaluate marketing performance. Without attribution models, they cannot identify "which channel/content actually drives conversions," leading to wasted marketing budgets. Fifth, privacy compliance risks. Due to the absence of dedicated data compliance teams, SMEs risk penalties from non-compliant user data collection practices.

- To address the aforementioned challenges, the practices in this chapter focus on solutions centered around "lightweight tools + scenario-specific solutions + compliance safeguards." For instance, Guangzhou C·H Control Technology Co., Ltd. assists a cosmetics brand in integrating omnichannel data and deepening customer insights, enabling the enterprise to achieve refined operations and intelligent decision-making. Meanwhile, Shenshan Medical Center has adopted Huawei's F5G-A 10Gigabit All-Optical Network solution, which effectively meets the hospital's critical demands for high bandwidth, seamless medical data interoperability, simplified operations and maintenance, and energy efficiency across all scenarios, thereby supporting its transition into a smart hospital.

- These practices demonstrate that by leveraging lightweight tools to lower technical barriers, implementing scenario-specific solutions tailored to actual needs, and incorporating compliance safeguards to mitigate risks, SMEs can effectively overcome the challenges of "incomplete data, high costs, poor results, and significant risks" in Customer Experience & Market Innovation, thereby establishing a virtuous cycle of "precision targeting – superior experience – sustained conversion."

CT Empowers Healthcare—Huawei F5.5G 10 Gbps FTTO Solution Enables High-Quality Development of Shenshan Medical Center

PRACTICE PROFILE

Shenshan Medical Center is a large-scale tertiary general hospital jointly funded by the Guangdong Provincial Government and Shenzhen Municipal Government. The hospital has a designed capacity of 800 beds, with 3500 outpatient visits, 1000 inpatient visits, and 100 surgeries per day. The bed occupancy rate is over 95%. Shenshan Medical Center aims to build a smart hospital and has proposed a strategic vision of developing a next-generation network platform. The network platform is expected to support multiple services, feature a simple architecture, be flexible and scalable, and provide ultra-high bandwidth, fully supporting the hospital's smart transformation. To meet the requirements, the hospital introduced Huawei's F5.5G FTTO solution, which effectively ensures high bandwidth, interconnection of medical data, convenient O&M, and energy saving in all scenarios of the hospital.

DETAILED DESCRIPTION

Solution Implementation Details »

F5.5G FTTO Solution for Hospitals Enables Smart Healthcare Applications

• After comparing multiple network solutions, Shenshan Medical Center chose Huawei's F5.5G FTTO solution to build the network foundation for a smart hospital. The project deployed six OLTs and 3098 ONUs.

• In terms of network architecture, Huawei's F5.5G FTTO solution uses optical fibers as the transmission medium. All networks (such as hall screens and ward call systems) of a department/section are carried by one optical fiber. The solution transforms the traditional hospital network from distributed to centralized, and from siloed to converged integration. A

unified hospital data center platform is built to obtain all medical information about patients in real time, including outpatient, inpatient, and physical examination data, eliminating data silos.

- In terms of energy consumption, the 10G FTTO solution uses passive optical splitters to replace traditional aggregation switches, making equipment rooms passive and eliminating the need for cooling devices such as air conditioners. The network is green and sustainable, and saves energy by about 30%.

- In terms of user experience, Huawei's 10G FTTO solution uses XGS-PON to provide 10G bandwidth to the image reading room, shortening the reading loading time from several minutes to seconds. Wi-Fi 7 optical APs are used to provide wireless coverage for wards. Each ward can

enjoy exclusive 10G bandwidth. The zero-roaming technology ensures that medical terminals, such as PDAs and medical carts, are not disconnected while on the move, improving work efficiency and reducing network complaints. Two OLTs are deployed in the core equipment room, and the Type B networking architecture is used to provide end-to-end link protection, ensuring 24/7 service availability in the hospital.
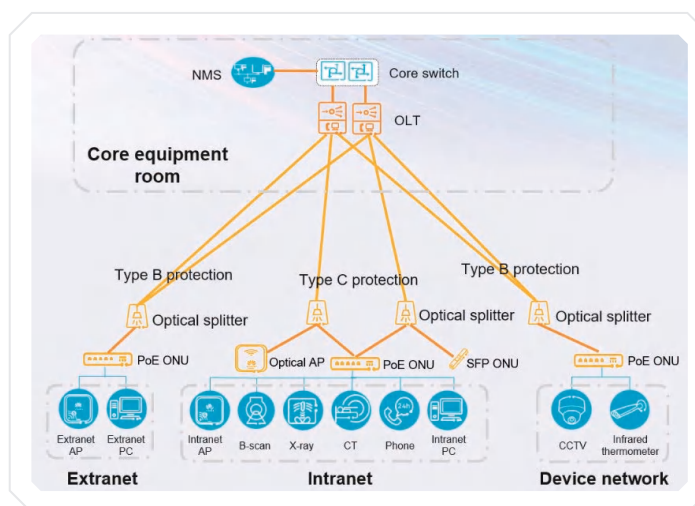
Outcomes Breakdown »

During the deployment of the F5.5G FTTO solution, the initial investment is estimated to be 20% to 30% lower than that of the traditional solution due to the simplified network architecture, less cabling, and lower equipment room device costs. Taking a single large department as an example, the initial construction costs can be reduced by hundreds of thousands to millions of RMB.

In terms of energy saving, passive optical splitters are used to replace active switches, saving 80% of equipment room space. The overall network energy consumption is expected to decrease by about 30%, and the energy consumption of a single ward can be reduced by more than 60%. The total energy consumption of the entire hospital is significantly reduced.

In terms of simplified O&M, all hospital departments share the same network. The cloud network management system is used for centralized management and one-click fault locating. The O&M efficiency is improved by up to 60%. One person can maintain the entire hospital network. IT engineers can focus on the development of higher-value applications. The O&M labor cost is expected to be reduced by 30% to 50%..

Value Proposition ≫

If each hospital department has its own independent network, cabling will be complex and management will be difficult. Limited by the 100-meter transmission of Ethernet cables, layer-by-layer aggregation will occupy more space, increasing power consumption and costs of the equipment room. Information silos will also hinder data sharing.

The F5.5G 10G FTTO solution uses optical fibers as the transmission medium. The optical fibers have high bearing capacity and small size, which help integrate and centrally manage multi-department networks. The network fault locating time is reduced from hours to minutes, reducing the troubleshooting time and cable trough space. Optical fibers have a high transmission capacity and can cover a distance of 20 km, which eliminates the problem of insufficient coverage in large hospital areas. The fiber transmission technology does not require layer-by-layer aggregation, saving space and energy consumption. Optical fibers are naturally immune to electromagnetic interference from sources such as CT rooms and X-ray rooms, as well as mutual interference between cables. Customers do not need to worry about signal shielding when constructing departments. In medical image reading scenarios such as digital pathology and magnetic resonance imaging (MRI), the ultra-high bandwidth of the FTTO network helps doctors reduce the image reading time from minutes to seconds..

IMPLEMENTING ENTITY PROFILE

Shenshan Medical Center, Memorial Hospital of Sun Yat-sen University ≫

Entity Type   Private sector

Core Business ≫

Shenshan Medical Center is a large-scale tertiary general hospital built by the Guangdong Provincial Party Committee and Provincial Government. After 3 to 5 years of full operation, the hospital will become a regional medical center specializing in medical treatment, education, and research.

AI-powered marketing technology empowers enterprises with omnichannel operations

PRACTICE PROFILE

Founded in 2004, **Legend Age** is a Chinese national cosmetics brand renowned for its "minimalist skincare" philosophy and the vision of "letting the world see Chinese beauty." With products ranging from lipsticks to skincare serums and lotions, Legend Age has expanded its reach to over 70 countries and regions globally. The brand primarily leverages **WeChat Mini Programs** (a proprietary transaction platform within WeChat) and a hybrid omni-channel sales network comprising online and offline distributors.

Legend Age meets 3 Challenges in Traditional Operations

1.Fuzzy User Profiling

Consumers were "familiar strangers"—while brand headquarters and distributors could access fragmented purchase data, they lacked insights into users' skin types, consumption scenarios, and emotional needs. Personalized marketing tailored to individual needs remained theoretical.

2.Decision-Making Blind Spots

Recruitment and distributor promotions lacked data-driven support. Identifying high-potential partners and growth pathways was akin to navigating in fog, with no clear metrics to evaluate performance.

3.Resource Fragmentation

Membership assets were scattered across WeChat Mini Programs, offline stores, and distributor systems, resembling "scattered pearls" rather than a cohesive competitive advantage.

By deploying the **AI Marketing Cloud**, Legend Age achieved transformative improvements:

1.Unified Digital Ecosystem

Data Integration: Aggregated real-time transaction data from WeChat Mini Programs, offline store feedback, and distributor sales into a centralized "Brand Digital Asset Pool," eliminating data silos.

PRACTICE PROFILE

3D User Profiling: Evolved from basic demographics (gender, age) to behavioral psychology insights, capturing lifestyle scenarios (e.g., "office workers seeking overnight hydration") to drive hyper-personalized campaigns.

2.Data-Driven Decision Empowerment

Distributor Growth Radar: Analyzed many metrics—including historical purchase frequency, regional sales performance, and social community engagement—to identify high-potential distributors. AI-generated customized support plans (e.g., targeted training, bestseller bundles) shortened promotion cycles by 40%.

Precision Customer Acquisition: Leveraged social graph analysis to pinpoint communities dense with beauty influencers (KOCs). Regional distributors received tailored "community viral toolkits," enabling a closed-loop strategy: **headquarters campaign design → regional execution → consumer word-of-mouth amplification.**

3.Mindshare Building over Traffic Exploitation

AI-Powered Personalization: Analyzed browsing and cart-abandonment behaviors to deliver "customized skincare regimens."

Offline-Online Synergy: Integrated skin diagnostic tools at physical counters with AI recommendations, boosting repeat purchase rates.

DETAILED DESCRIPTION

Solution Implementation Details »

This system **AI Marketing Cloud** specializes in **integrating omnichannel data** and **deepening customer insights** to empower enterprises with granular operational management and **intelligent decision-making**. It supports real-time capture of behavioral data across Apps, Mini Programs, H5 pages, and other full-channel touchpoints, comprehensively mapping user journey pathways; through OneID-based unified identification capability, it breaks down data silos, aggregates cross-platform information, and constructs 360° comprehensive user profiles. Additionally, it enables dynamic tag generation and precise user segmentation with over 10 grouping strategies including clustering and RFM analysis, enhancing targeted user operations. The system provides intelligent analysis and decision support, embedding multi-dimensional models covering event analysis, funnel analysis, retention analysis, and user lifecycle management, while leveraging AI to output optimized strategic recommendations. Its attribution tracking function quantifies the contribution of user behaviors to final conversion goals, effectively guiding the optimization of

advertising placements and marketing campaign strategies. Furthermore, it drives automated marketing outreach via a Marketing Automation (MA) engine for full-scenario operations, supporting multi-channel synergy across WeChat, SMS, email, etc., to achieve personalized "one-size-fits-one" push effects. Deeply rooted in private domain operations, it integrates closely with WeChat Work SCRM tools, dedicated to boosting user engagement and conversion efficiency within private domains.
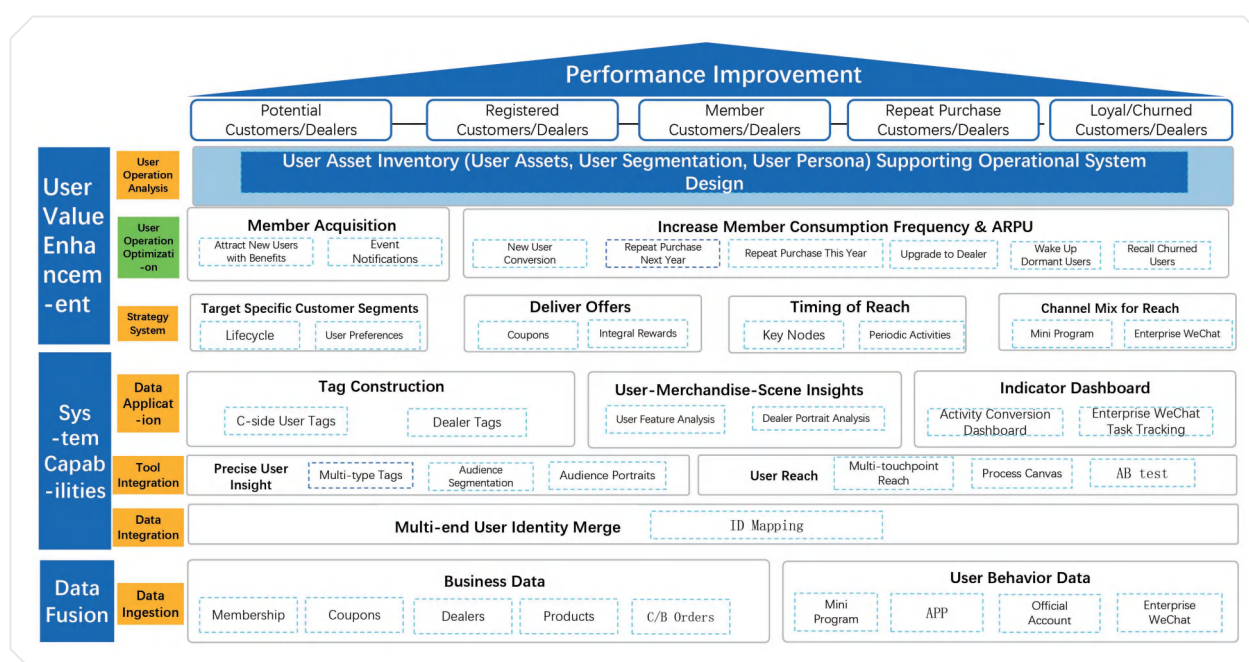
Outcomes Breakdown »

After implementing the AI Marketing Cloud, significant enhancements were observed across multiple operational dimensions: The enterprise WeChat friend-adding rate for marketing initiatives increased by over 35% (achieved through unified WeChat tooling for individual account targeting in China); dealer-side panels displayed real-time customer dynamics, boosting targeted communication efficiency by 50%+ while shortening high-intent customer conversion cycles to within 3 days. The automated distribution system intelligently identified users with expiring coupons, triggering dealer task reminders for group message campaigns directing users to mini-program redemptions, achieving 90%+ task reach rates, 20%+ message click improvements, and 40%+ redemption rate gains versus manual processes. Marketing material production cycles compressed from 3 days to 1 hour, increasing dealer material utilization by 80%+. Parameterized link materials (e.g., promotional H5s) generated average click-through rates exceeding 22%, driving 3x ROI improvements for campaigns. Consumer repurchase rates rose by 30%, with private

domain users averaging 1.5 additional monthly purchases. Dealers managed 100+ more clients per capita, while headquarters achieved 60%+ efficiency gains in regional marketing oversight.
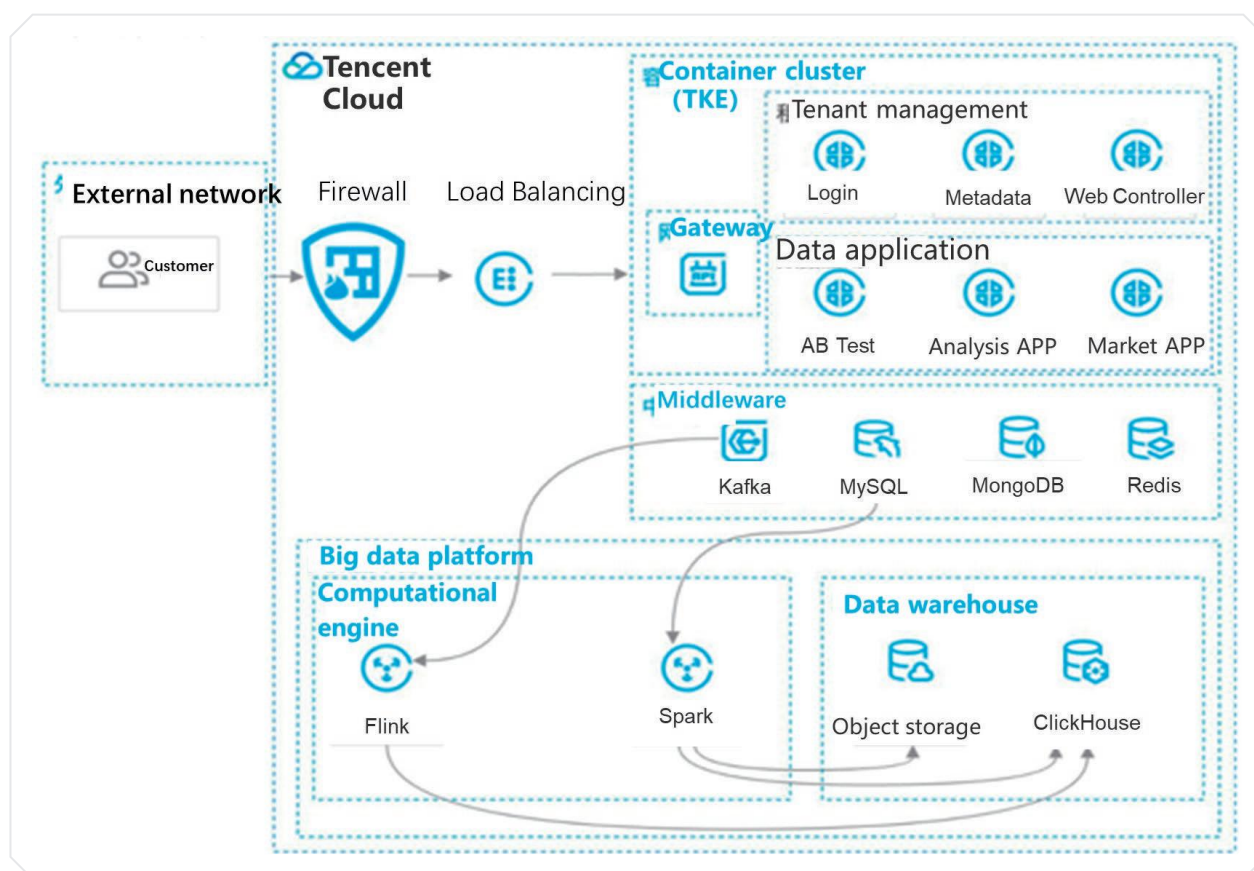
Value Proposition ≫

In today's hyper-competitive retail landscape, brands increasingly face challenges with fragmented membership data, ineffective data utilization, and stagnant growth. This calls for an intelligent system capable of managing member lifecycle operations while enabling precision automated marketing strategies. The AI Marketing Cloud addresses these needs through industry-customizable audience segmentation frameworks and analytical models, empowering brands to holistically analyze membership data and rapidly deploy targeted marketing campaigns across diverse segments. Supporting both private and hybrid cloud deployments with elastic scalability (minimum hardware requirement: 88 CPU cores, 176GB RAM, plus complementary database middleware), the system features an intuitive interface that allows marketers to configure rules for automated execution while providing real-time operational dashboards for performance monitoring. For global expansion initiatives, the platform integrates overseas sales data to construct comprehensive global member profiles, seamlessly connecting with international

communication channels to facilitate cross-border membership marketing - driving conversions, repeat purchases, and viral growth through localized automated campaigns.

IMPLEMENTING ENTITY PROFILE

Guangzhou C·H Control Technology Co.,Ltd. »

Entity Type Private sector

Core Business »

For formula-based manufacturing enterprises in the beauty and cosmetics, daily chemical products, health care products, food, pharmaceuticals + fine chemicals (4+1) industries, we provide overall planning and technical services for smart factories, including integrated software and hardware solutions such as MES, WMS, QMS, PCS (process batch control), SCADA, production line automation, intelligent logistics (AGV), intelligent vertical warehouse, energy control, public and auxiliary energy conservation, CSV (GMP computerized system validation), AI applications, etc

MANUFACTURING & OPERATIONAL EFFICIENCY ENHANCEMENT

03

2025

Chapter 3: Manufacturing & Operational Efficiency Enhancement

CHAPTER OVERVIEW

- SMEs worldwide are accelerating the digital transformation of Manufacturing & Operational Efficiency Enhancement, with intelligent production lines and flexible manufacturing systems emerging as core development directions. Technologies such as the industrial internet, big data analytics, 5G, and AI are deeply applied across scenarios including real-time monitoring, intelligent production scheduling, quality traceability, and supply chain collaboration. For instance, AI-powered visual inspection systems now enable high-precision defect identification, while Automated Guided Vehicles (AGVs) significantly enhance material handling efficiency. These technologies not only drive substantial productivity gains but also make dynamic balance between customized production and large-scale manufacturing achievable—marking a new paradigm shift toward "intelligent manufacturing."

- SMEs in developing countries are particularly focused on enhancing competitiveness through digitalization, yet their transformation faces multiple challenges: First, limited financing channels and insufficient fixed asset investment hinder technological upgrades. Second, on the technological front, companies often struggle due to low automation levels and the dual demands of simultaneously pursuing automation and digitalization. Third, a shortage of technical talents and the lack of specialized teams with both digital skills and management expertise result in superficial transformation depth. Fourth, in terms of management, traditional models and mindsets struggle to adapt to digital requirements, with weak capabilities in data integration and utilization, and prominent issues of fragmented and isolated information systems. Fifth, volatile policy environments further exacerbate operational risks. These factors collectively lead to high digital transformation costs and low success rates, often trapping enterprises in the misconception of "technology stacking" without a feasible path compatible with local conditions.

- Addressing the aforementioned challenges, the practices in this chapter demonstrate solutions centered on "moderate automation" and "platform-based, lightweight approaches." China Telecom Shenzhen Branch, in collaboration with ecosystem partners, developed an

integrated ERP and MES solution for WELL Electric, restructuring business processes through data flow integration to remove barriers between planning and execution layers. Beijing Qycx Network Technology Co., Ltd. utilized narrowband video transmission to support 200 high-definition video streams over just 2Mbps bandwidth, enabling remote collaboration between the robotic dog production base and R&D center while increasing production efficiency by over 30%. Lamipak has implemented a 10Gigabit all-optical network by replacing traditional copper cables with optical fiber and simplifying the network architecture. This initiative has not only enabled high-efficiency production and green development but has also delivered significant economic benefits. In a separate case, China Telecom, Shenzhen High-Tech Zone Information Network Co., Ltd., partnered with Kingdee Group and Cantact Information Technology to conduct a full-process diagnosis for Weier Electric Appliance. This collaboration successfully broke down data silos and established a data-driven production model, ultimately achieving the goal of "increased efficiency, reduced costs, and improved quality."

• These practices highlight the advantages of data-driven and modular deployment approaches. Through coordinated efforts among government, enterprises, and technology service providers, they deliver low-threshold, highly adaptable transformation pathways for SMEs, promoting the sustainable development of intelligent manufacturing ecosystems.

5G+Beidou Integration Empowers Rizhao Port's Energy Industry to Unleash New-Quality Productive Forces

PRACTICE PROFILE

Rizhao Port in Shandong Province gives full play to its advantages in crude oil operations, focuses on the core links of crude oil distribution and transshipment, and advances the digital upgrading of the entire chain to ensure the safe and efficient operation of 4 crude oil terminals (each with a 300,000-ton capacity), 7 major storage areas and 5 key pipeline networks.

To meet the port's needs of improving safety management efficiency and reducing operating costs, based on 5G and satellite navigation technologies, it has built China's first 5G + low-orbit satellite sea surface coverage private network. Combined with a high-precision spatiotemporal data platform, this network has effectively solved the technical problem of multipath effect in marine positioning, realizing centimeter-level accurate positioning of personnel, real-time trajectory tracking and automation of intelligent inspection.

These technological innovations and applications have promoted the transformation and upgrading of traditional ports to smart ports, provided a successful example for the digital transformation of industries such as petrochemicals, and boosted the technological progress and sustainable development of related industries.

DETAILED DESCRIPTION

Solution Implementation Details »

Guided by the core concept of "laying a solid foundation through dual-network integration and enabling precise empowerment via digital intelligence", targeted solutions have been developed

to address pain points in the crude oil operation area of Rizhao Port, such as semi-obstructed environments and weak offshore signals.

1.Laying a solid foundation through dual-network integration: Construction of Beidou + UWB multi-source fusion positioning and 5G satellite private network in sea areas. This initiative breaks through traditional technical bottlenecks. A Beidou + UWB multi-source fusion algorithm has been developed, which integrates signal field strength and distortion characteristics to solve the "flying point" problem in marine positioning, achieving 360° seamless centimeter-level positioning (accuracy < 10cm) both indoors and outdoors. Simultaneously, China's first 5G + low-orbit satellite private network in sea areas has been built, providing ultra-long coverage of 40km to ensure data transmission from offshore platforms. This forms a spatial perception base with complementary "communication + positioning" dual networks.

2.Empowerment via spatiotemporal platform: IoT data integration and intelligent function calling. Relying on a spatiotemporal service platform, IoT data is integrated to provide support for function calls such as trajectory tracking and intelligent inspection.

3.Precise application of digital intelligence: In-depth empowerment of production links and full-link risk supervision. The system deeply empowers core production links including crude oil distribution and transshipment, realizing real-time risk early warning and visualized data supervision. It not only connects the full link of "perception - transmission - calculation - application" to solve problems such as positioning drift at crude oil terminals and delayed offshore communication, but also provides underlying support for the port's digital and intelligent transformation. This helps Rizhao Port build an international crude oil distribution hub and drives the leap of new-quality productive forces.
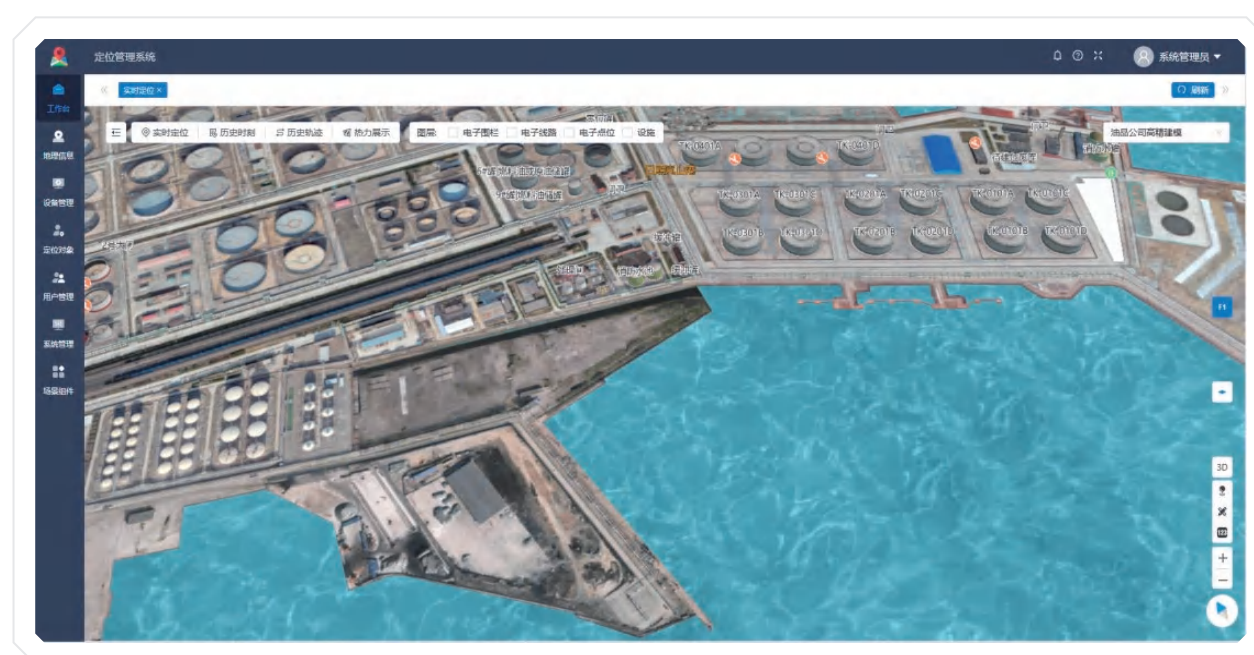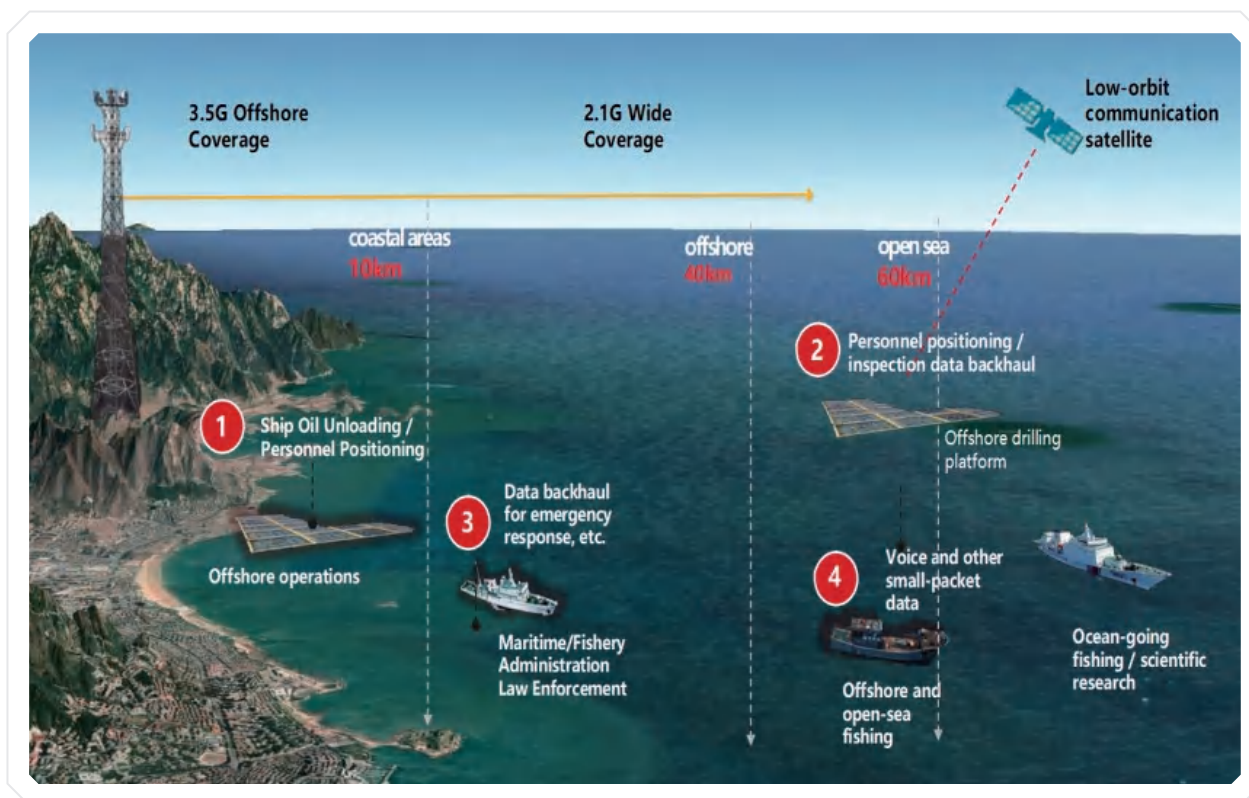
Outcomes Breakdown »

The digital and intelligent upgrading of the project has unleashed multiple benefits: its annual crude oil handling capacity has reached 8 million tons, a historic high, and the rising throughput has driven regional economic growth; unit costs have decreased by 15%, energy consumption has dropped by more than 20%, resulting in annual energy cost savings of tens of millions of yuan; per capita efficiency has increased by 30%, and the stable operation rate has maintained 100%, ensuring steady production capacity. At the same time, a smart system integrating "5G + Beidou + low-orbit satellites" has been built, and functions such as real-time positioning and intelligent inspection have solidified the bottom line of safety—chemical accidents have been reduced to zero, and centimeter-level trajectory tracking and safety early warnings have safeguarded the safety of over 2,000 workers, aligning with SDG 12 ("Responsible Consumption and Production"). Intelligent sensors dynamically monitor oil pollution and water quality; there have been zero crude oil leaks throughout the year, and the excellent rate of inshore sea water quality has reached 100%, protecting the marine ecology and contributing to SDG 14 ("Life Below Water"). With its practices of safety, intensification and green development, the project provides a model for global port transformation and advances the implementation of the Sustainable Development Goals (SDGs).

Value Proposition »

It boasts outstanding industry generalization capabilities: its positioning technology breaks through the scenario limitations of single energy ports and is compatible with multiple types of scenarios such as terminals, warehouses, and logistics centers. The threshold for resource requirements is low: algorithm optimization reduces the deployment of UWB base stations, resulting in low construction costs and short cycles, which adapts to the investment of enterprises of different scales. Its lightweight and fast-implementation features meet the digital transformation needs of international small and medium-sized ports and hazardous chemical enterprises. It has been replicated and promoted in the internal subsidiaries of Rizhao Port, verifying its portability. Conforming to the global trend of port safety and green transformation, it contributes to SDGs Goals 11 (Sustainable Cities and Communities) and 14 (Life Below Water). Moreover, it provides a low-cost and highly adaptable digital and intelligent safety solution for energy ports along the "Belt and Road" initiative, demonstrating significant potential for international promotion.

IMPLEMENTING ENTITY PROFILE

China Unicom Smart City Research Institute »

Entity Type State-owned Enterprise

中国联通
China unicom

Core Business »

As a directly affiliated consulting and R&D institution of China Unicom focusing on the industrial internet and smart city sectors, it centers on planning consultation, product R&D, and technological innovation. It refines the core "5G + Beidou" products, makes breakthroughs in communication-navigation integration technology, and empowers the digital transformation of thousands of industries.

Narrowband video transmission technology empowers the production of robot dogs

PRACTICE PROFILE

When conducting remote collaboration between two locations, it is often difficult to promptly grasp the on-site situation due to the numerous video streams and high costs of network transmission infrastructure. Moreover, the sluggish loading of the video images further hampers efficiency.

However, with the help of the narrowband video transmission system, **200** video streams can be efficiently integrated without the need to increase additional bandwidth costs, allowing for smooth cross-city transmission. Production progress, equipment demonstrations, and part tests, among other video images, can be accessed at any time by simply opening the equipment, making the operation as convenient as being on-site and easily breaking through the obstacles caused by distance in collaboration.

DETAILED DESCRIPTION

Solution Implementation Details »

Breaking through the barrier of remote collaboration! Qingyang Narrowband Technology collaborates seamlessly with Beijing's robot dogs in research and production.

The cross-regional collaboration between the Jiangsu robot dog production base and the universities in Beijing has achieved a leapfrog upgrade from "distance obstruction" to "seamless collaboration" thanks to the empowerment of Qingyang Narrowband Video Transmission System.

To meet the monitoring requirements of the base perimeter and the production line, the system sets transmission terminals at two centralized monitoring points, compressing massive monitoring videos into 2M narrowband streams, and efficiently transmitting them to the central computer room. The universities in Beijing only need one Qingyangdispatching terminal, which connects to

base computer room via the public network. With 2M bandwidth, they can view all monitoring images in real time, and at a glance, they can understand the production line progress and the safety status of the base. Remote supervision is as convenient as being on-site.

During the key component testing phase, to capture subtle crack changes, each testing machine is equipped with 2000W pixel Aiqiong industrial cameras, which collect test images at a frequency of 6 frames per second. The teachers from Beijing remotely access the real-time data of the corresponding testing machine through the dedicated software, accurately analyze the part status, and provide high-definition and timely visual support for research and improvement, completely eliminating the problems of "data lag and inefficient analysis".

What is even more notable is that for mobile equipment such as robot dogs and unmanned vehicles, Qingyang customizes compatible boards and embeds them in the equipment, combined with dual-camera systems. It can not only collect operation images in real time but also quickly process data by combining machine vision algorithms. The video is simultaneously transmitted to the command vehicle, allowing the command personnel to grasp the equipment dynamics in real time, providing strong support for remote technical guidance and operation scheduling.

From production supervision to research and testing, and to the control of mobile equipment, Qingyang Narrowband Technology, with its advantages of low bandwidth, high clarity, and strong adaptability, has broken through the collaboration barriers between Jiangsu and Beijing, enabling efficient collaboration in the research and production of robot dogs across different regions!
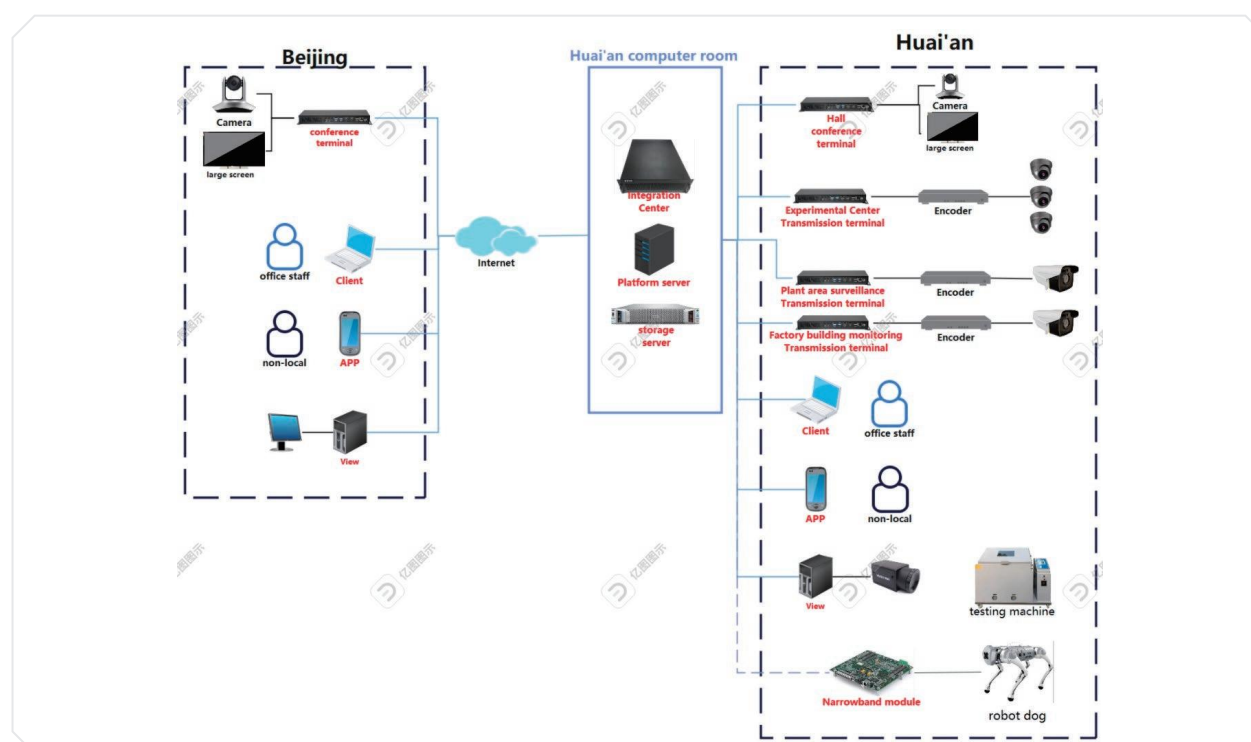
Outcomes Breakdown »

This project effectively solved the core problem of 200 video streams' remote transmission between the machine dog production base in Jiangsu and a certain university in Beijing by deploying the Qingyang Narrowband Video Transmission System. This achieved significant economic benefits. In terms of bandwidth costs, the system merged and compressed the videos from multiple scenarios such as the base perimeter and production lines into a 2Mbps bandwidth for transmission, saving over 100 video streams' bandwidth usage compared to the traditional solution, significantly reducing public network transmission and operation expenses. In terms of personnel costs, the professor in Beijing no longer needed to frequently travel between the two locations, reducing travel expenses by over 500,000 yuan per year. At the same time, remote control of production progress and guidance of component testing were achieved, reducing production rework caused by communication lag, and the production line efficiency increased by over 30%. Additionally, the industrial camera data acquisition and machine dog board card compatibility solution did not require the purchase of additional dedicated transmission equipment, was compatible with the existing collaboration process, and avoided duplicate investment.

In terms of social benefits, the project provided efficient technical support for the collaboration between industry, academia, and research: The Beijing research team obtained real-time data from 2000W pixel industrial cameras in the production line and laboratory through the system, reducing the data acquisition cycle from the original **3** days to real-time, accelerating the iteration of machine dog machine vision algorithms, and has helped implement **2** technological improvements. In industrial applications, the customized board card and dual-camera compatibility solution promoted the intelligent upgrade of mobile equipment such as machine dogs and unmanned vehicles, and its low-bandwidth transmission capability provided replicable experience for remote supervision of similar equipment. At the same time, the "production – research – application" remote collaboration model built by the project promoted the transformation of university technology achievements into the industry, strengthened the collaborative innovation capabilities between universities and enterprises, set a benchmark for the integrated development of industry-academia-research in the intelligent manufacturing field, and facilitated the digital transformation of the high-end equipment manufacturing industry.

Value Proposition »

The Qingyang Narrowband Remote Collaboration Solution Empowers the Comprehensive Upgrade of Industry-University-Research and Intelligent Manufacturing

The successful collaboration between Jiangsu - Beijing Robot Base is just the "starting point" of the Qingyang Narrowband Video Transmission System - This solution, with its strong adaptability, cutting-edge technology strength and low threshold advantages, is becoming an "efficiency accelerator" in the field of industry-university-research collaboration and intelligent manufacturing, with its promotion value within reach!

In the field of industry-university-research, it completely breaks the barrier of "research in universities, production in different locations"! Whether it is remote test guidance during automotive component research and development, real-time quality control in electronic chip production, or the full-screen image transmission of new material experiments, it can achieve high-frequency technical interaction with low bandwidth. University teams no longer need to travel, and can precisely control the production and testing details of the off-site industrial base, easily solving the industry pain point of "separation of research and production", doubling the efficiency of university-enterprise cooperation.

In the field of intelligent manufacturing, it is even a "universal adapter king" for multiple scenarios! Cross-regional supervision of multiple factory areas in discrete manufacturing enterprises, remote quality control in continuous production enterprises, can all be stably supported by 2Mbps low bandwidth; the combination of custom boards + dual-camera can not only be the "thousand-mile eyes" of robots, unmanned vehicles, but also be embedded in industrial robots, intelligent AGV and other equipment, making mobile devices have both visual perception and remote control capabilities, helping equipment manufacturing reach the "intelligent connection" new stage.

More importantly, the implementation threshold is extremely low! There is no need to modify existing equipment and networks, it is compatible with mainstream industrial cameras and monitoring equipment on the market, and small manufacturing enterprises and research institutions can be quickly deployed, enjoying efficient collaboration at a low cost. From industry-university-research to intelligent manufacturing, the "real-time transmission, precise control, easy implementation" model constructed by the Qingyang Narrowband Solution is becoming a benchmark choice for digital transformation.

IMPLEMENTING ENTITY PROFILE

Beijing Qingyang
Times Technology Development Co., Ltd. »

Entity Type   Private sector

Core Business »

Qingyang Era Technology Co., Ltd. is a leading company in the field of narrowband video transmission technology in China. It specializes in the research and development of video compression, transmission, and intelligent control technologies in low-bandwidth environments. Qingyang Era Technology Co., Ltd. is a prominent player in the narrowband video transmission technology sector in China, focusing on the research and development of video compression, transmission, and intelligent control technologies in low-bandwidth environments. The core team consists of video coding and communication technology experts from renowned universities and top research institutions, and they have been deeply engaged in the industry with over **10** years of technical accumulation.

Adhering to the mission of "innovation-driven security supervision", we focus on key fields such as energy, transportation, and government affairs, providing full-chain narrowband video solutions from front-end equipment to central platforms. In scenarios with low bandwidth, high security, and strong compatibility, we have accumulated mature technical advantages and implementation experience. Our core products have also passed multiple national-level technical certifications, using their strength to safeguard the remote supervision needs of various industries.

F5G-A Empowers Manufacturing: Accelerating Intelligent Manufacturing for Lamipak

PRACTICE PROFILE

Lamipak (Kunshan) Co., Ltd. has 750 employees. In the past, the factory's copper network had insufficient bandwidth, poor reliability, complex networking, and difficult O&M, affecting intelligent production and office efficiency. Therefore, the F5.5G 10 Gbps FTTM solution was adopted. The network system construction started in July 2025 and the project was delivered within three months. The solution integrates the production, office, and security networks into one, providing high speed, low latency, and high stability and reliability. The subsequent maintenance and upgrade are also easier. The new network makes the factory run more smoothly and improves production efficiency, laying a solid foundation for future intelligent development.

DETAILED DESCRIPTION

Solution Implementation Details　》》

A flexible and reliable solution that uses the all-optical technology, enabling more efficient smart manufacturing

Based on the high standards of the all-digital smart factory, Lamipak selects the F5.5G FTTM solution. The GPON, XGS-PON, and 50G PON passive optical network technologies are used to flexibly meet bandwidth requirements of different factory areas. In the overall architecture, the office, production, and security networks are integrated into one physical network, and the traditional three-layer network structure is simplified to two layers. Only two OLTs and 94 ONUs are used.

To meet the reliability requirements of intelligent manufacturing, the three networks use dual links to ensure 24/7 service availability. The innovative PON hard isolation slicing technology ensures that different types of data traffic do not interfere with each other and are securely isolated. 50G PON access is used for the office network with high bandwidth requirements to ensure VIP digital office experience. For the production network with ultra-high reliability requirements, optical fibers are directly connected to machines, industrial-grade devices are used, and OLT stacking and dual fed and selective receiving are used to fully protect each link, ensuring ultra-high reliability of the manufacturing process. For the security network with flexible power supply requirements, PoE devices that can directly supply power to cameras are used to simplify cabling and improve deployment efficiency. In terms of O&M, the visualized cloud management platform makes O&M management clear and flexible.

The solution ensures smooth upgrade over the next decade with a flexible all-optical architecture, eliminating the need for large-scale re-cabling. This provides a solid and efficient network foundation for Lamipak's long-term intelligent development.
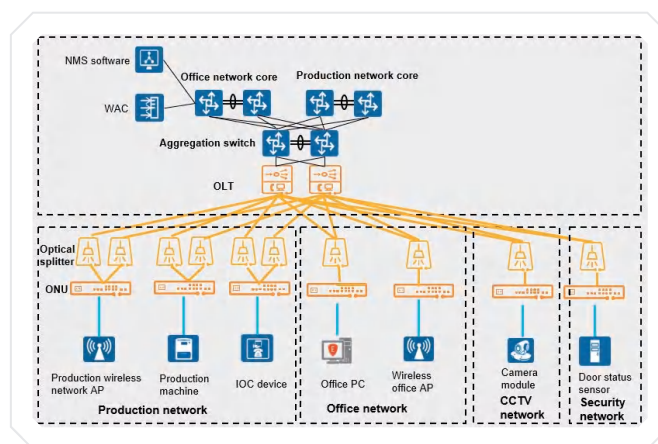
Outcomes Breakdown »

Lamipak deployed the F5.5G 10G FTTM network, which not only enabled efficient production and green development, but also brought significant economic benefits. Optical fibers are used to replace traditional copper cables, simplifying the architecture. Passive components achieve zero power consumption. The energy-saving technology reduces the overall energy consumption by 30% and saves 80% of cables and space. Every 1000 data points can save 60 km of cables and reduce carbon emissions by about 1.33 tons. In terms of economic benefits, the efficient and reliable FTTM network enables intelligent and efficient production, achieving an annual growth of 10% in per capita output. It also supports the rapid expansion of the company's business with 340 customers in more than 80 countries worldwide, with sales revenue increasing by as much as 64%. Thanks to the convergence of the three networks and the simplified FTTM architecture, the network O&M cost is reduced by 50% annually, and the unit cost can be reduced by 4% annually, bringing competitive advantages and long-term benefits to the company.

Value Proposition »

Lamipak faces challenges such as low device networking rate, data silos, difficult production line adjustment, low network reliability, and difficult O&M. These are the common pain points in the manufacturing industry. To address this issue, the F5.5G 10G FTTM solution is introduced.

In this solution, optical fibers are routed directly to machines, and passive optical splitters are used to simplify the architecture. ONUs are plug-and-play, meeting the access requirements of flexible production. Optical fibers are inherently immune to electromagnetic interference. Together with OLT stacking and dual-fed and selective-receiving for end-to-end service protection, a highly reliable network is built to ensure service availability around the clock. In this solution, the entire factory is managed by one network. O&M personnel can configure devices on the entire network using service templates, greatly improving O&M efficiency.

This solution not only accurately addresses the three common challenges in the industry, that is, low reliability, difficult to realize flexible production, and difficult O&M, but also provides an ideal path for the intelligent upgrade of the manufacturing industry with a short ROI period of two to three years.

IMPLEMENTING ENTITY PROFILE

Lamipak (Kunshan) Co., Ltd. »

Entity Type   Startups and SMEs

Core Business »

Founded in 2007, Lamipak specializes in aseptic packaging solutions. It is now a global industry leader, with products sold in 87 countries. Lamipak sets standards for innovation and quality, ensuring product safety and freshness.

Digital Transformation Empowers Weier Electric to Achieve Efficient R&D, Production, Supply-Sales Collaboration and Quality Leap.

PRACTICE PROFILE

Weier Electric, founded in 1997, is a National High-Tech Enterprise specializing in R&D, production, and sales of Intelligent Transportation Systems (ITS). Its core business covers public safety products (e.g., breathalyzers, radar speed guns, law enforcement recorders), smart recognition technologies, and ITS solutions, dedicated to providing one-stop "Safe City" services.

For years, the company has faced the following challenges:

- **Severe Data Silos:** The outdated ERP system only manages backend operations like finance and procurement, while workshop production data relies on paper reports, preventing real-time progress tracking for management. The disconnect between material requirements planning and workshop execution led to simultaneous inventory overstocking and material shortages.

- **Inefficient Quality Traceability:** With a product defect rate of 2%, quality issue identification required manual checks across multiple systems, averaging 3 hours per case.

- **Prolonged Delivery Cycles:** Production scheduling depended on manual experience, frequent emergency orders disrupted workflows, and the average order delivery cycle reached 30 days, driving up customer complaints.

In June 2025, China Telecom and Shenzhen High-Tech Zone Information Network partnered with Kingdee Group and Canta Information Technology to conduct a full-process diagnosis of the supply chain and production. Aligning with the Smart Manufacturing Capability Maturity Model and SME Digital Transformation Standards, they addressed critical pain points in R&D, planning, production, and quality. By breaking down data silos and reconstructing production management with data-driven approaches, the project delivered the triple value of "efficiency gain-cost reduction-quality improvement."

PRACTICE PROFILE

This initiative not only accelerated Weier Electric's digital transformation but also enhanced production efficiency and management standards, offering replicable success models for the electronics manufacturing industry's multi-process collaboration and high-precision traceability needs.

DETAILED DESCRIPTION

Solution Implementation Details 》》

Focus on addressing data silos issues, and implement the digital transformation of management systems and production processes.

China Telecom and Gaoxin Network have conducted process optimization and transformation for their core supply chain systems and production processes, with specific measures and solutions including:

- **Process Redesign:** Data flow-oriented business process redesign to eliminate inter-departmental data barriers
Establishment of data sharing incentive mechanisms

- **System Integration:** Integration of document flow, business flow, and data flow between ERP and MES systems

- **Closed-loop "plan-execute-feedback" cycle for business collaboration:**
ERP synchronizes production orders and BOM to MES
MES breaks down into process work orders and collects production data in real-time
Completion information is fed back to ERP
Bidirectional data flow characteristics achieved

- **Results:**
70% reduction in data entry time
Cost accounting cycle shortened from monthly to weekly
80% reduction in material shortage-related downtime
Through the integration of Enterprise Resource Planning (ERP) and Manufacturing Execution

- **Systems (MES) via APIs or middleware, this implementation:**

Significantly improves operational efficiency
Enhances decision-making quality
Strengthens risk control
Lays the data foundation for smart manufacturing
Enables transition from experience-driven to data-driven operations

Outcomes Breakdown ≫

Specific benefits and values include:

1、Integration of ERP and MES follows the closed-loop logic of "Plan-Execute-Feedback" to form a clear business flow

The ERP system generates the Master Production Schedule (MPS) and Material Requirements Planning (MRP) based on sales orders and forecasts, synchronizing production orders (including product codes, quantities, delivery dates, etc.) and Bill of Materials (BOM) to MES. This eliminates manual data entry, reduces repetitive work, achieves real-time collaboration between production planning and execution, and shortens order delivery cycles by 30-50%.

2、Improvement in Decision-Making Quality

Management gains a complete view of "Plan-Execute," enabling dynamic resource allocation. The finance department accurately calculates costs based on real-time production data, reducing the cost accounting cycle from weeks to days. Quality traceability is enhanced, and the recall scope of defective products can be precisely pinpointed to specific processes.

3、Strengthened Risk Control

Real-time monitoring of material availability prevents production interruptions (reducing material

shortage stoppages by 80%). Automatic alerts for deviations in process parameters reduce quality incident response times from hours to minutes. Bidirectional synchronization of inventory data achieves consistency between records and physical inventory (reducing inventory discrepancy rates from 5% to 0.3%).

4、Foundation for Continuous Improvement

Accumulating comprehensive production big data supports AI-driven process optimization, forms the basis for digital twins, and lays the data foundation for future production simulation and predictive maintenance, providing data infrastructure for smart manufacturing upgrades.

5、Achievement of Data-Driven Decision-Making and System Integration

Through the visualization of production operation data, data silos between ERP, MES, and WMS are eliminated, creating a unified analytical platform. This avoids information isolation and improves cross-departmental collaboration efficiency.

Value Proposition »

Weier Electric's Flexible Production Model Validates the Integrated Solution as a Digital Transformation Benchmark for SMEs in Discrete Manufacturing.

Weier Electric's ERP/MES/WMS Integrated Transformation Project

The recent ERP/MES/WMS integrated transformation project implemented by Weier Electric achieves closed-loop management of planning, production, and quality through multi-system data integration. Adopting a dual-channel integration approach (API + intermediate database) ensures data real-time performance and system fault tolerance.

This solution eliminates extensive manual recording and data entry, providing a pragmatic and efficient digital transformation path for enterprises. Its experience holds significant reference and promotion value for manufacturing enterprises.

Project Value Includes:

- **Operational Efficiency Improvement:**

Order delivery cycle reduced from 30 to 20 days

Customer complaint rate decreased by 60%

Manual workload for workshop reports reduced by 80%

Inventory turnover rate increased by 35%

- **Quality Cost Optimization:**

Product defect rate reduced from 2% to 0.5%

Annual quality loss reduced by approximately ¥3 million

After-sales repair traceability efficiency improved by 90%

Customer satisfaction score reached 4.8/5

- **Core Value of ERP-MES Integration:**

By breaking down data silos, the integration achieves deep synergy between enterprise resource planning and manufacturing execution systems, establishing a "planning-execution-feedback" closed-loop management mechanism. This combination of ERP's global resource optimization capability and MES's shop-floor real-time control enables precise decomposition of production plans into process work orders while providing real-time feedback on equipment status and quality data to management.

For enterprise digital transformation, this integration lays the data foundation for smart manufacturing, supporting AI-driven process optimization through comprehensive production big data accumulation. It forms digital twin capabilities, enabling the transition from experience-driven to data-driven operations, ultimately building an agile, transparent, and intelligent manufacturing operation system to comprehensively enhance market responsiveness and core competitiveness.

IMPLEMENTING ENTITY PROFILE

(1) China Telecom Shenzhen Branch
(2) ShenzhenHigh-tech Zone
Information Network Co., Ltd. »

Entity Type
(1) High-tech enterprises
(2) technology-based small and medium-sized enterprises

Core Business »

China Telecom Shenzhen Branch

As a key branch of China Telecom in Shenzhen, China Telecom Shenzhen Branch has consistently ranked first in revenue among China Telecom's prefecture-level branches for many years, leading the nation in 5G construction and application. The company has been actively promoting the implementation of 5G, cloud computing, big data, and Internet of Things (IoT) technologies.
It has fully implemented the new "Cloud Transformation, Digital Shift, and Intelligent Empowerment" strategy, building a comprehensive intelligent cloud capability system integrating "computing power, platform, data, models, and applications" to support the digital transformation of the manufacturing industry. This has significantly driven the digital transformation of industrial manufacturing in Shenzhen and surrounding areas, providing robust technical support and solutions for high-quality development in the manufacturing sector.

Shenzhen High-Tech Zone Information Network Co., Ltd.

As a member of China Telecom Group and a national high-tech enterprise, Shenzhen High-Tech Zone Information Network Co., Ltd. leverages 5G private networks, industrial internet platforms, and AIoT technologies to provide full-chain digital services for manufacturing enterprises, including smart factory data collection (with millisecond-level latency transmission), AI quality inspection, predictive maintenance, and flexible production management.
The company possesses CMMI-DEV V2.0 ML5 international certification for R&D capabilities and has independently developed three core systems: an IoT perception platform and a smart government information platform. Through deep collaboration with Fortune 500 companies like Huawei and ZTE, the company has helped clients in industries such as shipbuilding and steel achieve a 40% increase in production efficiency and a 30% reduction in defect rates..

PRODUCT/SERVICE INNOVATION

04

2025

Chapter 4: New Paradigms in Product R&D and Services

CHAPTER OVERVIEW

- Amid the global digital economy wave, Product/Service Innovation have become core pathways for SMEs to break through competitive saturation and achieve high-quality development. The deep integration of ICT technologies—such as cloud computing, AI, IoT, and big data—is fundamentally reshaping traditional innovation models: Digital tools enhance the efficiency and precision of product development. Digital twin technology shifts product testing from the physical to the virtual realm, significantly reducing trial-and-error costs. Cloud computing and big data enable real-time data sharing and collaborative design, shortening R&D cycles. Generative AI accelerates product design and optimization, rapidly transforming ideas into prototypes with a leap in design efficiency. Cloud-native development and low-code platforms remove technical resource barriers, allowing SMEs to access top-tier toolchains through subscription-based, modular approaches.

- However, the digital transformation of product R&D and services is no straightforward journey. SMEs in developing countries face multiple challenges: firstly, inadequate internal R&D information management systems and limited capabilities in building foundational R&D databases hinder their data collaboration capacity; secondly, a shortage of versatile talents coupled with high licensing costs for advanced tools creates a dual constraint; thirdly, the conflict between long-cycle investments and short-term cash flow pressures forces many enterprises to abandon innovation initiatives. These challenges form invisible yet formidable technological barriers, excluding numerous SMEs from the wave of digital transformation.

- Addressing the aforementioned challenges, the practices in this chapter demonstrate solutions centered on "moderate automation" and "platform-based, lightweight approaches." For instance, China Mobile (Jiangxi) Virtual Reality Technology Co., Ltd.'s "Digital Transformation Enablement Solution for SMEs" leverages China Mobile's Capability Middle Platform and industrial internet infrastructure to build a "1+3+N" product supply system: one-stop digital transformation application marketplace, serving three types of entities including SMEs, and developing N key products to drive comprehensive upgrades in the

manufacturing sector.

- Beijing Qycx Network Technology Co., Ltd.'s "Narrowband Video Transmission Technology Empowering PV New Energy" has established a comprehensive cross-regional monitoring system through a full-chain architecture of "front-end comprehensive coverage collection + back-end centralized processing + terminal visual presentation." This solution precisely addresses the management needs of large-scale PV projects, achieving panoramic penetration monitoring across 200 project sites and booster stations. The system enables cross-regional dispatch with an on-site management experience, setting a new benchmark for efficient operation in new energy projects.

Digital Intelligence-Driven · Innovative Services—— Empowerment Solution for Digital Transformation of SMEs

PRACTICE PROFILE

In recent years, China's industrial sector has achieved rapid development, and the digital transformation of small and medium-sized enterprises (SMEs) has been in full swing. China Mobile has comprehensively advanced the digital transformation of SMEs by securing the "three guarantees" of organizational teams, infrastructure, and frontline services, deepening the "three approaches" of strengthening benchmarks at the "point" level, building operation platforms at the "line" level, and promoting cluster development at the "area" level, and enhancing the "three innovations" of AI products, application scenarios, and industry models. Since 2024, it has completed digital diagnosis for over 5,100 enterprises, facilitated digital transformation for more than 3,500 enterprises, and built over 1,000 national and provincial-level benchmark enterprises, providing strong support for the digital transformation of SMEs.

DETAILED DESCRIPTION

Solution Implementation Details »

To address the pain points of small and medium-sized enterprises (SMEs) – "daring not to transform, unwilling to transform, and not knowing how to transform" – Jiangxi Mobile has developed a digital transformation solution aligned with the concepts of the UN Sustainable Development Goals (SDGs). Leveraging China Mobile's capability platform and industrial internet infrastructure, it has built a "1+3+N" product supply system: 1 digital transformation application supermarket, serving 3 types of entities including SMEs, and developing N key products to facilitate the comprehensive upgrading of the manufacturing industry.

Relying on the Jiangxi Industrial Internet Platform, the solution integrates seven core capabilities such as cloud, network, and AI, and provides three service models – SaaS-based deployment, on-premises deployment, and all-in-one equipment. It realizes digital inclusiveness with low costs and low thresholds, solving the difficulties faced by enterprises in transformation. Meanwhile, a public service platform for government digital transformation has been built to promote collaboration among governments, enterprises, and service providers, which is in line with the SDG concepts of "sustainable economic growth" and "improving global governance".

Independently developed by the Industrial Internet Research Institute of Jiangxi Mobile, the solution ensures the effectiveness of transformation through dedicated R&D support teams and a full-process service mechanism. It empowers SMEs to upgrade, serves the local economy, and contributes a Chinese solution to the digital transformation of SMEs worldwide.

Outcomes Breakdown »

In terms of economic benefits, the solution strictly controls the transformation costs of small and medium-sized enterprises (SMEs) through the "cloud adoption with scale" model. It improves implementation efficiency via large-scale replication, connects all links of R&D, production, supply, sales and services, and breaks down data silos, helping enterprises increase their overall production efficiency by an average of 20%. Since 2024, it has driven the signing of digital transformation projects worth 1.2 billion yuan across 12 key industrial chains, served over 3,000 enterprises, and fostered more than 1,000 industry benchmarks.

In terms of social benefits, the solution is aligned with the UN Sustainable Development Goals (SDGs). It contributes to Goal 8 (Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all) and Goal 9 (Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation). Moreover, its efficient collaboration and optimal resource allocation also support Goal 7 (Ensure access to affordable, reliable, sustainable and modern energy for all) and Goal 13 (Take urgent action to combat climate change and its impacts), advancing the green and sustainable development of industries.

Focusing on Key Work Has Initially Shown Results

Promote Large-scale Transformation	On-site Enterprise Diagnosis Completed On-site Diagnosis for Manufacturing Enterprises **Total** **Over 5,000**	Enterprise Transformation Serve the Transformation of Large-scale Manufacturing Enterprises **Total** **Over 3,500**	Standard Implementation and Certification Promote Enterprises to Complete Standard Implementation and Certification **Total** **Over 3,100**
Establish a Service System	Digital Transformation Team Establish the Scale of the Digital Transformation Service Team **Over 10,000**	Digital Transformation Clinic Participate in the Construction and Operation of Digital Clinics Across the Province **34**	Digital Transformation Promotion Center Serve the Provincial Digital Transformation Promotion Center **14**
Build an Industry Benchmark	National-level Benchmark Helped 16 enterprises be included in the 2024 5G Factory Directory, with a proportion in the province **73%**	Provincial-level Benchmark Served 85 provincial-level 'Little Beacon' and digital intelligent factory enterprises, accounting for a proportion of **47%**	Smart Factory Empowers 33% of Jiangxi Province's Advanced-level Smart Factories, with a total of **60**

Value Proposition »

The solution boasts outstanding generalization capabilities. Its full-process standardized product modules can be quickly adapted to enterprises of different scales, facilitating promotion. The "1+3+N" product system covers multiple industrial chains, while models such as SaaS-based deployment and on-premises deployment can adapt to different enterprises and be flexibly implemented in scenarios like production and supply chains.The deployment threshold is low – it can operate on a terminal with 16 cores and 500GB storage, and costs can be reduced by leveraging existing hardware. Standardized delivery lessens reliance on professional talents, enabling quick application results and a short investment payback period.Currently, it has served over 3,500 enterprises. It not only meets the low-cost needs of developing countries in Southeast Asia and beyond but also can be customized to adapt to scenarios in developed countries. Combining universality and flexibility, it has great promotion potential.

IMPLEMENTING ENTITY PROFILE

China Mobile
(Jiangxi) Virtual Reality Technology Co., Ltd. »

Entity Type State-Owned Enterprise

Core Business »

China Mobile Group-level Innovation Center is committed to basic research on **VR** technology applications, the application of key core technologies, and support for the digital transformation of the manufacturing industry. It has obtained many honors such as being recognized as a National High-Tech Enterprise.

Narrowband video transmission technology helps promote photovoltaic new energy

PRACTICE PROFILE

As a benchmark project for regional new energy development, the 500MW grid-connected photovoltaic project covers 200 scattered plots and 1 core substation. It is of a grand scale and has a dispersed layout, serving as a "trial stone" for the refined management in the photovoltaic industry.

Due to its inherent characteristics of scattered plots and extensive coverage, real-time cross-regional supervision and simultaneous status synchronization at multiple locations have become challenging issues. The traditional model is unable to balance the coverage breadth and control accuracy, and the delayed response in remote scheduling greatly restricts the operational efficiency of the project.

An innovative "front-end full coverage collection + back-end centralized processing + terminal visualization presentation" full-chain remote monitoring system has been established, precisely matching the management requirements of large-scale photovoltaic projects, achieving full-area penetration supervision of 200 plots and the substation, and making remote scheduling feel like being on-site, thus setting a new benchmark for the efficient operation of new energy projects.

DETAILED DESCRIPTION

Solution Implementation Details »

Regulation of Photovoltaic Projects Has Been Upgraded! Full-Chain Architecture Solves the Problem of Multi-Plot Management Difficulties

To solve the problem of 200 scattered photovoltaic plots and the difficulty of cross-regional management, the project has established a remote supervision system with "full coverage, efficient transmission, and flexible viewing", making remote management convenient and efficient.

In terms of monitoring coverage, high-definition controllable monitoring devices have been installed in key areas such as photovoltaic panels, entrances and exits, equipment areas, and power station substations of the 200 plots. These devices can capture 1080P high-definition images and can be magnified 20 times for details and rotated 360 degrees, enabling clear viewing of whether the photovoltaic panels are damaged or stained, as well as tracking the cross-plot movement of personnel and vehicles, ensuring that every corner can be monitored. This provides a clear picture for remote viewing and ensures that the images are stable and the data is traceable. In the data transmission and processing stage, the monitoring data of each plot is first aggregated through the local network and then transmitted uniformly to the power station via optical cables. With the help of an exclusive transmission system, these scattered videos will be compressed and integrated, significantly reducing transmission costs; at the same time, all equipment can be centrally managed, and the videos can be saved for more than 30 days, facilitating subsequent traceability, ensuring a stable image and traceable data during remote viewing. The viewing method is also very flexible: the large screen in the control room can simultaneously display the images of multiple plots, and by simply clicking one button, the image of a certain plot or a certain device can be enlarged and focused. Managers can carry a portable terminal, connect to the network and verify their identities, and then view the real-time video of the designated plot from anywhere. The image switching and magnification are very convenient, completely eliminating the limitation of only being able to supervise in fixed locations.

The entire system does not need to modify the existing facilities. From plot monitoring to remote viewing, the process is smooth, solving the pain points of multi-plot management and significantly improving management efficiency.
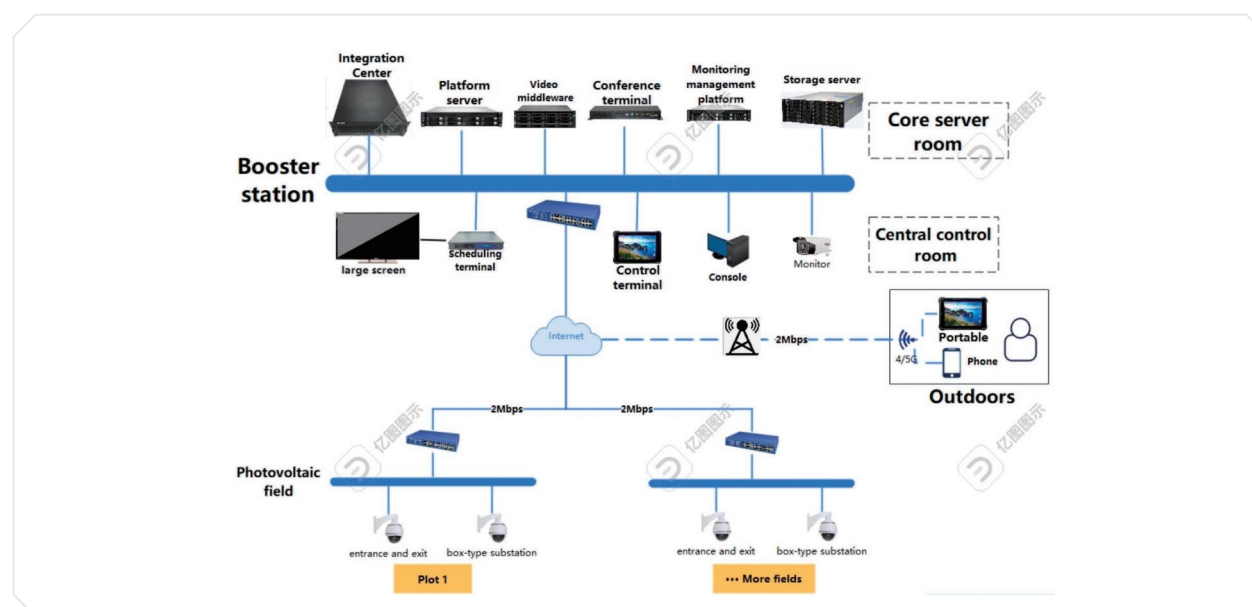
Outcomes Breakdown »

After adopting the clear and narrow-band video transmission system, the problem that traditional mobile devices could not support video viewing of over 200 plots has been completely solved. Through the "two-level integration" technology, multiple plot videos are compressed into low-bandwidth streams, significantly reducing the cost of remote transmission, and no additional deployment of mobile transmission hardware is required. Managers can view videos anytime and anywhere through portable terminals, reducing on-site inspection travel and manpower investment. The annual savings in operation and maintenance costs exceed 300,000 yuan. At the same time, the system is compatible with existing platforms, avoiding redundant construction, further reducing project investment, and the investment recovery period is shortened to within 2 years.

Value Proposition »

Not just photovoltaics! Analysis of the cross-industry promotion value of the full-chain narrowband supervision solution

From the perspective of industry and application, this case, based on the Qingyang narrowband video transmission system, builds a remote supervision model with extremely strong promotion adaptability and practical value. In the renewable energy industry, its distributed photovoltaic multi-site and wide-range supervision solution can be directly replicated to wind power, energy storage power stations and other projects, especially suitable for remote areas and decentralized energy facilities, solving the pain points of insufficient bandwidth and limited coverage in traditional mobile supervision.

In terms of application extension, the system's low bandwidth and multi-terminal adaptability can be extended to fields such as smart agriculture (remote monitoring of greenhouse clusters), mining (multiple mining areas safety supervision), and water conservancy projects (full-domain control of basin sites), meeting the mobile and low-cost supervision needs of various decentralized scenarios.

In addition, its "reuse compatibility + two-level integration" technical path reduces the renovation threshold and investment cost for industry customers, is easily accepted by small energy enterprises and cross-regional operating units, and provides a feasible benchmark solution for promoting the digitalization supervision upgrade of distributed scenarios in various industries.

IMPLEMENTING ENTITY PROFILE

Beijing Qingyang
Times Technology Development Co., Ltd. »

Entity Type Private sector

Core Business »

Qingyang Era Technology Co., Ltd. is a leading company in the field of narrowband video transmission technology in China. It specializes in the research and development of video compression, transmission, and intelligent control technologies in low-bandwidth environments. Qingyang Era Technology Co., Ltd. is a prominent player in the narrowband video transmission technology sector in China, focusing on the research and development of video compression, transmission, and intelligent control technologies in low-bandwidth environments. The core team consists of video coding and communication technology experts from renowned universities and top research institutions, and they have been deeply engaged in the industry with over 10 years of technical accumulation.

Adhering to the mission of "innovation-driven security supervision", we focus on key fields such as energy, transportation, and government affairs, providing full-chain narrowband video solutions from front-end equipment to central platforms. In scenarios with low bandwidth, high security, and strong compatibility, we have accumulated mature technical advantages and implementation experience. Our core products have also passed multiple national-level technical certifications, using their strength to safeguard the remote supervision needs of various industries.

AI-POWERED INNOVATION

05

2025

Chapter 5: AI-Driven Innovation

CHAPTER OVERVIEW

• AI is reshaping the global industrial competitive landscape, emerging as a core driving force behind the digital transformation of SMEs. According to WTO forecasts, AI is projected to boost global trade growth by nearly 40% by 2040, primarily by reducing trade costs, enhancing supply chain efficiency, and empowering SMEs to compete globally. Today, AI applications are evolving from single-function tools to integrated solutions across the entire value chain, with typical use cases spanning intelligent manufacturing systems, supply chain optimization, customer interaction, and decision support. Notably, the emergence of generative AI and open-source large models has significantly lowered technical barriers, enabling SMEs to bridge the technological gap with industry leaders at lower costs.

• However, SMEs in developing countries face three structural contradictions in AI adoption. First, the contradiction between technological advancement and limited resources: weak computing infrastructure, inadequate data governance capabilities, and a shortage of AI talents create a dilemma where businesses are "unable, incapable, or hesitant to adopt." Second, the contradiction between model standardization and scenario fragmentation: general-purpose AI models struggle to adapt to the non-standardized needs of niche manufacturing sectors, while tacit knowledge is difficult to translate into training data, leading to a mismatch between technological supply and industry demand. Third, the contradiction between technological value and ecosystem lag: AI service providers tend to focus on high-return sectors, marginalizing medium- to long-term manufacturing applications. At the same time, the lack of a tiered service ecosystem makes project-based deliveries inadequate for sustaining continuous iteration. These contradictions are further exacerbated in developing countries by policy instability and digital infrastructure gaps, potentially widening global disparities in digital trade.

• In response to the aforementioned challenges, this chapter presents five illustrative practices that collectively underscore the pivotal role of ICT, particularly artificial intelligence, in advancing the digital transformation of SMEs. These include: the AI-powered digital foundation developed by OUC Online Education & Information Technology Co., Ltd. for online education enterprises; the intelligent security services for parks by Shenzhen Chuangshi

Hulian Technology Co., Ltd.; the 3DBIAO AI data annotation platform for the building decoration industry by Shenzhen Changhong Intelligent Technology Co., Ltd.; the Huadu District New Industrialization Digital Service Platform empowering SME transformation; and the AI-enabled cultivation of industrial technical talent by the China Branch of BRICS Institute of Future Networks. Together, these cases demonstrate how targeted technological applications are driving efficiency, innovation, and capability building across diverse sectors.

- Together, they demonstrate the core role of ICT technologies, particularly AI, in advancing the digital transformation of SMEs. These practices deeply integrate the Sustainable Development Goals (SDGs), generating positive social impacts in areas such as educational inclusivity, safety governance, and green, low-carbon development. Through their replicable models, they provide inclusive and agile digital transformation pathways for SMEs worldwide, highlighting the broad potential of technological empowerment.

AI Digital Infrastructure Driving the Digital Transformation of Online Education Enterprises

PRACTICE PROFILE

Current artificial intelligence technologies are driving the transformation of online education toward ubiquity, personalization, and intelligence. However, deep application faces three core challenges: the management gap, the skills gap, and the data gap. Through in-depth research and technological breakthroughs, Guokai Online has proposed a systematic solution for building an AI digital foundation. This involves organically integrating agent orchestration technology, workflow management systems, and core models/algorithms for processing teaching resources through an independently developed technical architecture. The result is an integrated intelligent hub covering the entire process of "teaching, learning, management, assessment, and service," supporting AI applications such as smart learning companions and intelligent assessment systems. Over three years, the project has incubated over 200 vertical-domain applications, serving 44 adult continuing education institutions. By integrating capabilities from multiple edtech enterprises, it has established a replicable "unified platform-tiered customization-ecosystem co-creation" model, delivering low-cost, high-efficiency AI solutions for educational institutions. The project was invited to exhibit at this year's World Digital Education Conference in Wuhan, receiving praise from Ministry of Education leaders and attracting international attention.

DETAILED DESCRIPTION

Solution Implementation Details »

Artificial Intelligence Digital Platform Empowers Full-Stack Intelligent Transformation Applications in Online Education

Following the principle of "Unified Hub, Layered Architecture, Agile Iteration," the solution builds a full-stack AI empowerment system for SMEs with the AI infrastructure as its core. It establishes a five-layer technical architecture:

- **IaaS Layer:** Provides high-performance computing and distributed storage.

- **PaaS Layer:** Integrates general and domain-specific large models, developing atomic capability components and standardized educational data assets.

- **EaaS Layer:** Transforms capabilities into personalized learning, intelligent teaching, assessment, and management engines.

- **APaaS Layer:** Delivers API gateways and low-code tools for rapid development and microservice governance.

- **SaaS Layer:** Focuses on five business scenarios—"learning, teaching, assessment, management, and services"—forming an intelligent closed-loop for operations and services.

RAG technology ensures real-time updates and accurate knowledge delivery, while the intelligent agent framework enables autonomous planning and execution of complex tasks, supporting continuous optimization through dual-track iteration.

The project is equipped with a product R&D team including 10 engineering PhDs. Through dedicated funding and institutional safeguards, it leverages the National Open University's existing database of over 5 million enrolled students—generating more than 100 million daily learning behavior records—alongside over 500,000 teaching resources reaching 44 pilot institutions nationwide. Having completed over 100 application validations, the team has developed a low-barrier, rapid-deployment, and replicable digital transformation pathway.
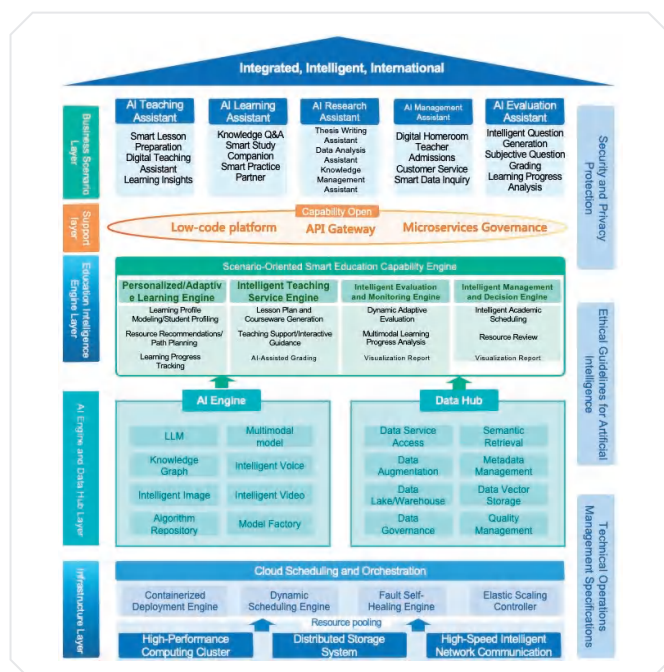
Outcomes Breakdown »

In terms of economic benefits, the smart base reduces hardware and labor barriers for educational institutions undergoing digital transformation through a unified hub and standardized interfaces. It boosts management efficiency by 40% and accelerates resource allocation response times by 60%. Services have been provided to 44 institutions, driving nearly 10 million yuan in industry R&D investment and securing over 40 million yuan in contracts for campus intelligence projects.

In terms of social benefits, the project serves lifelong learners, aligning with UN Sustainable Development Goals (SDGs) 4 (Quality Education), 9 (Industry, Innovation and Infrastructure), and 10 (Reduced Inequalities). The intelligent learning companion and age-friendly voice interaction promote educational inclusivity and equity. The security governance framework and data compliance mechanisms strengthen societal trust in AI applications. Related applications have been deployed on the National Smart Education Platform's lifelong learning section and regional platforms in Jilin, Hubei, Inner Mongolia, and others. Interconnectivity with 13 provincial platforms has been achieved, establishing a replicable model for cross-regional promotion and ecosystem co-construction..

Value Proposition »

Intelligent Education Framework Empowers Inclusive Digital Education Worldwide

In terms of industry-wide applicability, the project's application framework spanning five domains—teaching, learning, assessment, management, and services—exhibits universal adaptability. It accommodates the educational system requirements of diverse countries and regions through modular design enabling flexible configuration and localized customization.

Regarding resource thresholds, the project employs a cloud-native architecture to lower hardware barriers, supporting small-to-medium deployments with minimal configurations. Personnel skill requirements are relatively modest. Through a standardized training system and visual operation interface, general technical personnel can master the system after short-term training. The transformation investment payback period is approximately **18-24** months, achieving cost-benefit balance by enhancing teaching efficiency and management automation levels.

Regarding promotion prospects, the project's systematic promotion mechanism, standardized technical documentation, and continuous operation and maintenance support system provide reliable technical assurance and service foundations for international market expansion, offering promising prospects for promotion in the educational informatization markets of developing countries.

IMPLEMENTING ENTITY PROFILE

OUC Online Education & Information Technology Co., Ltd. »

Entity Type   Startups and SMEs

国开在线教育科技有限公司
OUC Online Education & Information Technology Co.，Ltd

Core Business »

For a decade, we have focused on the research, development, and service of online education technology, providing digital education solutions to 5 million students in open education. We are committed to becoming the leading industry benchmark in the field of lifelong learning.

Intelligent Security Services for Parks

PRACTICE PROFILE

An undetected hazard,a negligent patrol, or an unimplemented emergency plan could all become triggers for tragedy.The Park Safety Smart Defense Integrated System constructs a new security front by shifting from passive to proactive, fragmented to coordinated, and manual to intelligent approaches. Addressing latent park safety risks and outdated traditional security systems, it establishes a **'1+N+1'** security architecture. Through risk monitoring—enhanced by the Smart Defense Integrated System and a central control platform—real-time alerts and actionable response plans are generated. Utilizing cameras equipped with **AI** algorithms and hardware devices for rapid sensing, the system enables automated monitoring, intelligent alarms, and agile incident resolution for personnel, vehicles, assets, and events across multiple park zones. This transforms sites from passive surveillance to active defense, elevating overall security management capabilities.

DETAILED DESCRIPTION

Solution Implementation Details »

The Park Safety Intelligence Service Solution addresses critical pain points such as undetectable safety hazards, outdated traditional security systems, and low human efficiency. Centered on the philosophy of 'transforming safety from intelligent perception to intelligent defense,' it establishes a '1+N+1' security architecture (1 security large model + N safety management modules + 1 active defense brain). By leveraging IoT infrastructure for security situational awareness, the system integrates surveillance cameras, access control, fire alarms, and other devices. AI-powered risk monitoring enables real-time anomaly detection with automated alerts and response recommendations.

A comprehensive safety knowledge base—covering hazard databases, emergency plans, and regulatory compliance—supports data-driven decision-making. For hardware deployment, the solution features:

- Park Safety Smart Defense Integrated Machines
- Large Model Training-Inference Integrated Machines
- Maintaining compatibility with mainstream cameras for legacy equipment reuse
- Ensuring data security through localized deployment

Through security dashboards and mobile apps, managers gain holistic situational oversight. This solution applies to industrial parks, campuses, and complexes, effectively reducing accident risks and liability losses.

Outcomes Breakdown »

When the AI system initiates automatic warnings, security personnel transition from monitoring rooms to on-site response — shifting from reactive to proactive prevention. This system employs a deep learning framework trained on massive datasets encompassing park-wide safety scenarios (security, firefighting, flood/typhoon/emergency defenses, traffic management, small-scale construction projects, personnel safety). By analyzing nationwide safety cases, regulations, and standards, it accumulates experience surpassing any individual human operator — becoming a 24/7 'super employee'.

During emergencies, leveraging extensive knowledge databases and intelligent external data mining (e.g., resource availability, equipment status, weather conditions, legal risks), it combines high-speed computing power to analyze optimal solutions within milliseconds. This 24/7

operational 'super employee' functions as:

A safety expert assisting frontline staff with real-time problem resolution

An automated supervisor monitoring patrol quality, coverage, and contingency plan preparedness

A proactive auditor identifying issues and driving solutions

Resulting in >60% faster incident resolution and effective accident prevention.

Core Capabilities:

Real-time Monitoring & Rapid Response

Continuous multimodal surveillance detects risks instantly, triggering alerts and activating emergency protocols with task allocation guidance.

Process Documentation & Accountability

Standardizes responsibilities into actionable task checklists with full digital traceability, establishing duty fulfillment certification audit trails.

Risk Prediction & Prevention

Combines AI-powered hardware analytics with manual patrols to identify latent hazards for preemptive intervention.

Resource Optimization & Efficiency

Integrates AI with existing equipment for automated warnings, liberating human resources from routine monitoring while reducing labor costs by ≥30%.

Implementation Benefits:

- Localized deployment ensures data security
- Defense dashboards + mobile apps enable real-time oversight
- Accident evidence chain retrieval accelerated to minute-level
- Safety incident rates reduced by >50%.

Value Proposition »

AI-Powered Early Warning and Human-AI Collaboration Build a Resilient Digital Immune System for Full-Lifecycle Security

Employing modular architecture design enables high-efficiency replicability, allowing core functions (risk perception, response engine, audit certification) to be flexibly decoupled and rapidly deployed. Integrated with cross-industry security baseline template libraries and low-code O&M interfaces, institutions of all scales can adapt to 90% of scenarios with standardized solutions at minimal cost.

Digital inclusivity manifests through:

Resource-light architecture: Edge computing enables offline alerts in low-bandwidth regions

Barrier-free innovation: Multilingual interfaces eliminate access thresholds

Cost democratization: AI replaces manual monitoring, reducing SME operational costs to 1/5 of traditional solutions

Collective defense:

Shared threat intelligence pools enable class-agnostic security capability leaps

The system achieves systemic alignment with UN SDGs through an efficiency-equity-transparency

governance triad:

Federated learning optimization for privacy-preserving collaboration

Algorithmic bias rectification for equitable risk assessment

Generative decision reports for audit trail transparency

This constructs a sustainable foundation as the immune nexus for the digital era.

IMPLEMENTING ENTITY PROFILE

Shenzhen Chuangshi Hulan Technology Co., Ltd. »

Entity Type Startups and SMEs

Core Business »

With a security-focused approach, the '1+N+1' architecture equips cameras with AI algorithms and real-time sensing hardware. This enables automated monitoring, intelligent alerts, and agile response protocols for personnel, vehicles, assets, and events across multiple park zones. By transforming sites from passive surveillance to active defense against potential security incidents, it elevates comprehensive security management capabilities.

3DBIAO - AI Data Standard Platform for the Architectural Decoration Industry

PRACTICE PROFILE

3DBIAO Annotation Solves AIGC Dilemma, Empowers AI in Architectural Decoration
AIGC in the architectural decoration industry generally lacks design data with high-quality annotations (such as component types, dimensions, materials, and process requirements). Due to data deficiency, design outcomes cannot effectively drive refined and parameterized production, which limits AIGC's potential to improve industry efficiency and quality, and hinders the achievement of integrated design and manufacturing goals.

As a "translator" and "trainer" for data in the architectural decoration industry, 3DBIAO enables efficient and accurate annotation, providing critical data support for AI applications in the industry. It efficiently parses CAD, BIM, and point cloud data to generate structured annotation results containing design specifications, technical details, and intent information. It supports full-process management including project creation, task assignment, and annotation review, and can be exported in multiple formats to connect with large models.

DETAILED DESCRIPTION

Solution Implementation Details »

With Multi-Model Collaboration Technology as the Core, Realizing Full-Dimensional and Accurate Annotation of Architectural Decoration Data:

The core functions include drawing annotation (supporting CAD, point cloud, and BIM) and annotation management; auxiliary functions cover drawing asset management and AI training data supply.

- **At the data layer:** It collects both real data (such as CAD drawings and BIM models) and virtual data (generated from scenes and 3D assets) to build a "learning field".

- **At the inference layer:** Through the collaboration of different models, it completes target recognition, structural reasoning, and auxiliary annotation. It can also realize annotation visualization and connect to AI training platforms to generate drawings with millimeter-level precision.

The annotation information includes a structured annotation data knowledge graph covering full scenarios and multiple brands. This graph classifies annotations into four dimensions—node drawings, file information, content annotation, and file annotation—and further breaks them down into four levels (Level 1 to Level 4). It covers annotation information across multiple dimensions such as drawing name, material, model, process, industry category, and brand, enabling comprehensive and detailed annotation of relevant objects.
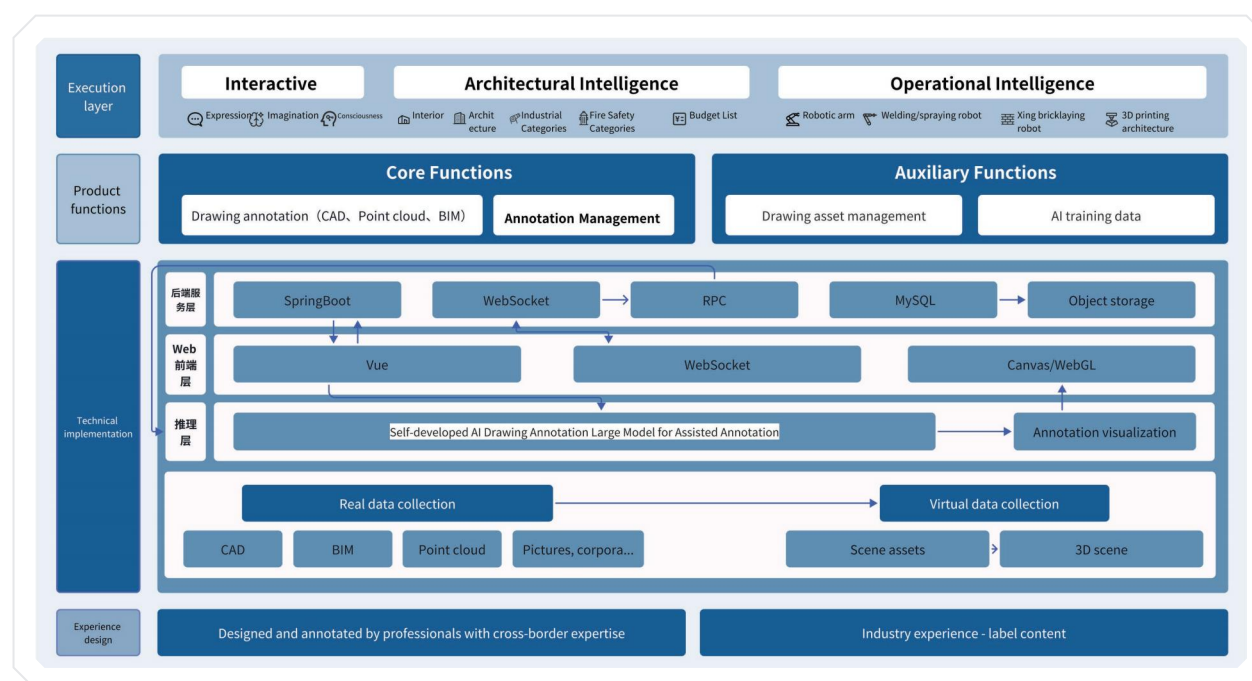
Outcomes Breakdown »

In the architectural decoration industry, AIGC suffers from a lack of high-quality annotated data, which restricts production and integration; There is also a shortage of professional annotation tools, making it difficult to meet complex needs and hindering intelligent development; Additionally, there is a data disconnect between the design and manufacturing processes, preventing AIGC solutions from directly serving production. As an industry data "translator" and "trainer", 3DBIAO enables efficient and accurate annotation, providing critical data support for AI applications in the architectural decoration industry.

3DBIAO efficiently parses CAD, BIM, and point cloud data, generating structured annotation results that include design specifications, technical details, and intent information. The coverage rate of annotation content reaches 95%, and the AI automation rate hits 80%. It supports 100% of relevant formats, achieves 99% AI compatibility, and covers 90% of application scenarios. With the goals of automated annotation, full-process management, and connection to training platforms, 3DBIAO drives the industry to break free from traditional models and move toward "AI-native" development. Annotated data will become the "neurons" of AI, ultimately building an "intelligent construction brain" and leading the upgrade of the architectural decoration industry.

Value Proposition ≫

Format adaptation capability, talent inclusiveness, environmental protection and carbon reduction 3DBIAO supports the export of 8 internationally used formats such as IFC, DWG, and JSON. Currently, it can connect to mainstream engineering software like Revit and CAD as well as general large models, without the need for secondary interface development.

SMMEs do not need to purchase multiple sets of standard software. They can complete drawing analysis for multiple countries through lightweight modules, and the cost of standard adaptation is immediately reduced by 40%.

Enterprises can organize training now to enable employees to quickly master the skills of handling multi-standard drawings.

It is open for free to colleges and universities in developing countries. Currently, no additional payment is required to participate in the training, which helps increase employment opportunities.

The platform supports AI in generating BIM models through data annotation. It helps architectural decoration enterprises quickly carry out BIM-based environmental design, reduce resource waste, and promote green and low-carbon development. It is expected to reduce carbon emissions by 10%-15% on average per project.

IMPLEMENTING ENTITY PROFILE

Shenzhen Changhong Intelligent Technology Co., Ltd. »

Entity Type Startups and SMEs

Core Business »

AI Data Annotation Platform for the Architectural Decoration Industry.

Breaking Barriers & Boosting Momentum : The Practice of Huadu District's New-type Industrialization Digital Service Platform in Empowering SMEs' Digital Transformation

PRACTICE PROFILE

Huadu District's New-type Industrialization Digital Service Platform (hereinafter referred to as the Platform) jointly built by the Huadu District Government and multiple enterprises including Huawei, PCI Technology, and Zealwon Technology, focuses on Huadu District's four key characteristic industries: electronic information, auto parts, cosmetics and daily care products, and leather goods. The Platform addresses digital transformation challenges through two main strategies. First, it eases the financial burden on enterprises with a tiered payment plan: free in the first year, 50% off in the second, and 30% off in the third. Second, the "community canteen" model, which allows selecting services like "ordering food", reduces costs and improves efficiency.With "modular procurement + lightweight deployment" as its core, it breaks down digital functions into flexibly combinable modules, cutting the cost of digital transformation by over 60% and forming a closed-loop of "policy guidance - enterprise participation - ecological co-construction".

By September 2025, the Platform had already supported over 300 SMEs. These enterprises have seen a 25% boost in production efficiency, a 30% drop in inventory turnover time, and a 60% cut in R&D time. This affordable and user-friendly approach offers a practical blueprint for digital transformation that other regions can easily adopt.

DETAILED DESCRIPTION

Solution Implementation Details »

AI for SMEs: "Diversified Collaboration + Full-Chain Coverage"
With industrial internet and industrial AI applications as its core driving forces, the platform is fully domestically developed, independent and controllable. It relies on Huawei Cloud AI Cloud Services for powerful computing power, adopts cutting-edge core technologies such as the Pangu Large Model, and is equipped with 50P computing power, thus building the AI empowerment model logic of "diversified collaboration + full-chain coverage".

- **Inclusive technology supply:** The Platform consolidates digital technology resources from industry leaders such as Huawei, offering SMEs a range of standard, budget-friendly options to choose as needed.
- **Platform-based enablement:** The Platform connects technologies, schedules resources, and shares data to break the technical barriers that block digital transformation for enterprises.
- **Collaboration among academia, industry, and research:** The Platform partners with the Fifth Electronics Research Institute of the Ministry of Industry and Information Technology (MIIT) to offer R&D support and talent training, enhancing SMEs' tech capabilities. It also targets regional industry clusters, optimizing digital connections along the supply chain to drive collaborative upgrades.
- **Ecosystem enablement:** Through the ecosystem of "government builds the platform, enterprises perform", the Platform gathers multi-party resources including policies, technologies, and capital, forming a positive-interaction ecosystem for digital transformation.
- **Service process:** The Platform follows a closed-loop approach—identify requirements, customize solutions, implement deployment, and track for optimization.
- **AI + digital marketing, building the brand HD-AI:** The Platform uses foundation models to analyze trends, plans marketing strategies, creates a user traffic pool for Huadu District, and supports cross-border marketing for SMEs. It also teams up with the China Certification & Inspection Group (CCIC) to set quality benchmarks in Huadu District.

Digital Service Platform for New Industrialization in Huadu District
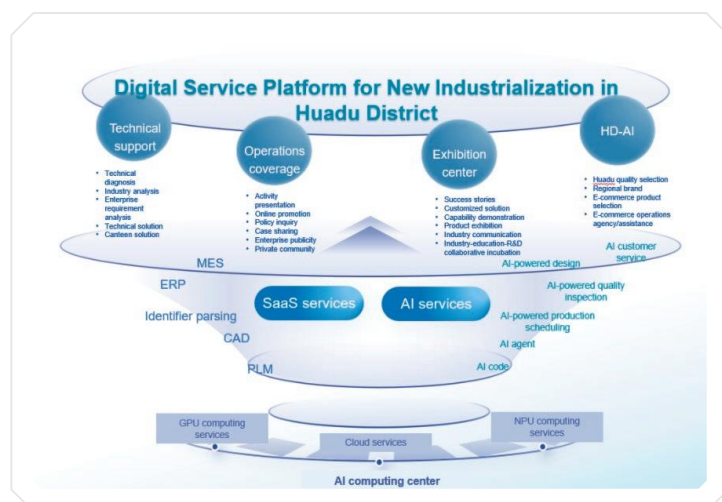
Outcomes Breakdown »

This project provides full support for the digital and intelligent transformation of SMEs in the region. The economic benefits include intensive construction of ICT resources, which reduces enterprise transformation investment and O&M costs. The Platform offers high-quality solutions as services, shortening deployment periods, lowering costs, and improving efficiency. In terms of social benefits, the project has established a multi-level public service system for SMEs, assisted the government in efficient supervision and management, created a demonstration model, empowered the industry, promoted the development of industrial clusters and the high-end development of industries, helped Huadu District build a digital talent echelon, and continuously improved the business environment.

Operated by Zealwon Technology, a state-owned enterprise in Huadu District, the Platform has driven cluster-based upgrades, validated the scalability of its replication model, and earned wide industry recognition. It was named an innovative case of industrial practice for New Quality Productive Forces in 2024, won the "Digital City Gold Prize" at the 8th Digital China Summit, and was officially approved in September 2025 as the National Center for Digital Transformation of Manufacturing Sector by the Ministry of Industry and Information Technology.

Value Proposition »

Sustainable Business Model & Easy Replication Across Industries and Regions
In terms of the sustainability of the business model, the tiered payment structure reduces reliance on government subsidies as enterprise transformation matures, encouraging independent investment and forming a virtuous cycle of "government cultivation – enterprise payment – platform profitability", which supports the Platform's long-term operations.

For cross-industry promotion, the modular technical solution addresses common needs of SMEs across industries. Modules can be flexibly combined and slightly adjusted to suit specific industry characteristics, enabling broad application.

The "government guidance + market operation" model is well-suited for cross-regional promotion. It can be tailored to fit local industrial structures and policy environments, particularly in regions with strong industrial clusters and limited digital infrastructure of SMEs. This model offers a scalable reference for advancing SMEs digital transformation nationwide.

IMPLEMENTING ENTITY PROFILE

(1) Huadu District Bureau of Science, Industry, and Information Technology
(2) Huawei Cloud Computing Technologies Co., Ltd.
(3) Guangzhou Zealwon Technology Co., Ltd. »

Entity Type
(1) Public sector
(2) Private Enterprise
(3) State-owned Enterprise

Core Business »

(1) Huadu District Bureau of Science, Industry, and Information Technology

The department serves as Huadu District's core driver of industrial and digital development. It manages technological innovation, industrial and information advancement, business and foreign trade, SME support, poverty alleviation cooperation, and market regulation

(2) Huawei Cloud Computing Technologies Co., Ltd.

Huawei Cloud shares Huawei's more than 30 years of technical expertise and product solutions in the ICT field, providing them to customers, partners, and developers through cloud services. Huawei Cloud is committed to providing stable, reliable, secure, and sustainable cloud services. In the AI era, Huawei Cloud focuses on AI and has blazed the trail to pioneer AI in industries.

(3) Guangzhou Zealwon Technology Co., Ltd.

Guangzhou Zealwon Technology Co., Ltd. is a state-owned information technology enterprise owned by Huadu District. Guided by its strategic orientation of "Deeply Rooted in Huadu, Extending to the Greater Bay Area, Serving the Nation",the company has developed four core businesses: digital services, operation of new industrialization digital service platforms, integrated vehicle-road-cloud solutions, and industrial chain platform construction. It is dedicated to facilitating government agencies, enterprises, and institutions in their digital transformation.

AI Empowers the Cultivation of Industrial Technical Professionals

PRACTICE PROFILE

Currently, industrial skills education in China faces multiple challenges, including highly homogenized online courses that struggle to meet the diverse needs of technical personnel at different skill levels, as well as a disconnect between teaching content and actual industry demands, leading to a misalignment between talent training and enterprise job requirements. Leveraging the advantages of AI technology, the China Branch of BRICS Institute of Future Networks (hereinafter referred to as the "BIFNC") has partnered with Shenzhen Jicheng Technology Co., Ltd. (hereinafter referred to as "Jicheng Technology") to jointly empower vocational education for technical professionals in China. Together, they are conducting in-depth exploration of innovation in online education models for the manufacturing sector. By fully utilizing years of online training experience and digital vocational education assets, they have built an online industrial vocational education platform based on a large-scale AI model—the Jicheng AI Agent. This platform provides trainees with fast and accurate vocational training services. Through the development of the Jicheng AI Agent, they aim to accelerate the iteration of high-quality digital training assets in the industrial sector, enable personalized teaching, reduce labor costs for services, improve teaching and service efficiency, and empower the high-quality development of industrial education and training.

DETAILED DESCRIPTION

Solution Implementation Details »

• **Solution Approach:** With a deep understanding of the operational principles and scenarios in industrial skills training, complex business scenarios are broken down into smaller, single-function modules. Suitable model architectures and algorithms are matched to construct an educational AI agent that integrates multiple refined functions. A series of innovative technical means are applied to enhance the model's capabilities, knowledge, and memory. Multiple agents are collaboratively

dispatched according to scenario requirements, enabling the model's capabilities to better serve the specific business contexts of technical skills training.

- **Technical Architecture:** The system's underlying layer integrates multimodal data parsing (text, images, audio, video) and knowledge graph construction with semantic indexing (Neo4j + FAISS/Milvus). The middle layer employs a RAG + LLM hybrid reasoning framework, utilizing LangChain for task orchestration and invocation among agents. The upper layer features human-computer collaboration and digital human interaction as the interface, enabling knowledge Q&A, adaptive assessments, teaching content generation, and multilingual courseware output. This provides a unified cognitive engine and service support for intelligent education scenarios.

- **Project Implementation Resources:** The project team consists of 1 Project Manager, 1 Front-end Engineer, and 5 AI Development Engineers. The large-scale AI model servers and data center facilities are provided by BIFNC. By appropriately incorporating internet-retrieved data and integrating it in real-time with leading industrial domain knowledge, the educational and training content is enriched. To address issues of "hallucination" and "insufficient expertise," a secure dedicated channel has been established. This enables safe and reliable access to Jicheng Technology's educational resources, including training videos, practical operation videos, industrial product manuals, engineer technical documents, and other multi-format, high-quality training materials.

AI for Good | Jicheng Intelligent Agent Functional Architecture

Jicheng Intelligent Agent

AI Q&A Intelligent Agent
- Multimodal Knowledge Base
- AI Large Language Model
- Retrieval-Augmented Generation
- Digital Human Cloning

AI Adaptive Learning Intelligent Agent
- Multimodal Knowledge Base
- Big Data Technology Analysis
- Retrieval-Augmented Generation
- Knowledge Graph

AI Course Content Generation Intelligent Agent
- Intelligent Script/Automatic Arrangement
- AI Large Language Model
- Intelligent Content Optimization and Proofreading
- Digital Human Cloning

AI Courseware and Video Translation Intelligent Agent
- Neuro-Linguistic Programming
- AI Translation Engine
- Multimodal Video Enhancement

Outcomes Breakdown »

- **Economic Benefits:** After system deployment, the introduction of the Q&A agent reduced the proportion of manual responses from 70% to 30%, cutting Q&A costs by approximately 60%–80% and increasing per-person service coverage by 2-3 times. Adaptive learning drove course completion rates and renewal/conversion rates up by about 5%–10%. Multi-language capabilities reduced video localization costs by 90%, shortening the turnaround time from "weeks" to "days," and enabling pilot incremental overseas orders. Under a lightweight operational configuration of "1x 3090-level GPU server + 1 part-time AI engineer," the monthly savings/incremental net benefits can cover operational costs, with an investment payback period of approximately 6–9 months and an annualized ROI of about 80%–150%.

- **Social Benefits:** By providing personalized learning paths and intelligent tutoring, the platform enhances the efficiency and quality of skills training. It significantly reduces the cost of specialized industrial education, enabling more workers to access high-quality vocational training and promoting educational equity. Simultaneously, it facilitates industrial talent upgrading, supplies suitable human resources for intelligent manufacturing, and supports industrial digital transformation and sustainable development.
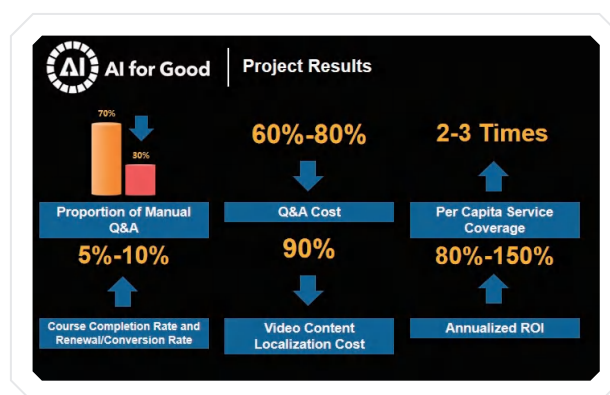
Value Proposition »

Firstly, the platform establishes a standardized intelligent training system. Upon completion, the large model can be horizontally adapted to meet the needs of corporate training, various vocational education programs, and certification. The technologies involved—such as knowledge graphs, multimodal retrieval, digital human avatars, multilingual subtitles and audio tracks, and adaptive learning path algorithms—also possess cross-industry applicability. This enables the company to expand into customized training across different sectors, enhancing the skill level of the global industrial workforce, and contributing to the internationalization of "China's Intelligent Manufacturing" standards. Secondly, the AI-powered personalized learning platform removes geographical barriers, providing efficient skills training to BRI countries. This will facilitate industrial capacity cooperation and the joint development of a technological ecosystem. Thirdly,

by cultivating interdisciplinary talents skilled in both "AI and industry," the initiative will strengthen the digital transformation capabilities of various nations' industrial sectors, and inject innovative momentum into global industrial upgrading while promoting the worldwide adoption of Chinese technical solutions and service models.

IMPLEMENTING ENTITY PROFILE

China Branch of BRICS Institute of Future Networks »

**Entity Type**   Academia/Research Institution

Core Business »

BIFNC is an international institution established through the consensus reached at the 9th BRICS Summit and approved at the 4th BRICS Communications Ministers Meeting. Jointly built by the Ministry of Industry and Information Technology of China and the Shenzhen Municipal People's Government, and operated by the Industry and Information Technology Bureau of Shenzhen Municipality and the China Academy of Information and Communications Technology, it was officially inaugurated in Shenzhen in August 2019 and commenced operations in June 2020. Guided by Xi Jinping Thought on Socialism with Chinese Characteristics for a New Era, BIFNC diligently implements the directives from General Secretary Xi Jinping at BRICS Summits, the consensuses of previous BRICS Summits, and the spirit of previous BRICS Communications Ministers Meetings. We thoroughly advance the strategic deployments of building China into a cyberpower, Digital China, and new industrialization. Rooted in Shenzhen, serving the nation, and engaging globally, we fully leverage both international and domestic markets and resources. Focusing on future networks and other ICT fields, we strive to build a professional think tank with international influence in future networks and a leading, exemplary platform for international exchange and cooperation. We aim to foster all-round practical cooperation among BRICS countries, emerging markets, and developing nations in technological innovation, application extension, standard formulation, policy research, industrial promotion, infrastructure development, international exchange and training, and talent cultivation related to future networks and ICT. Concurrently, we are committed to contributing to the Belt and Road Initiative, the "Going Global" strategy, and the development of the Guangdong-Hong Kong-Macao Greater Bay Area and the Pilot Demonstration Area of Socialism with Chinese Characteristics.

OTHER
EMERGING TECHNOLOGY
APPLICATION
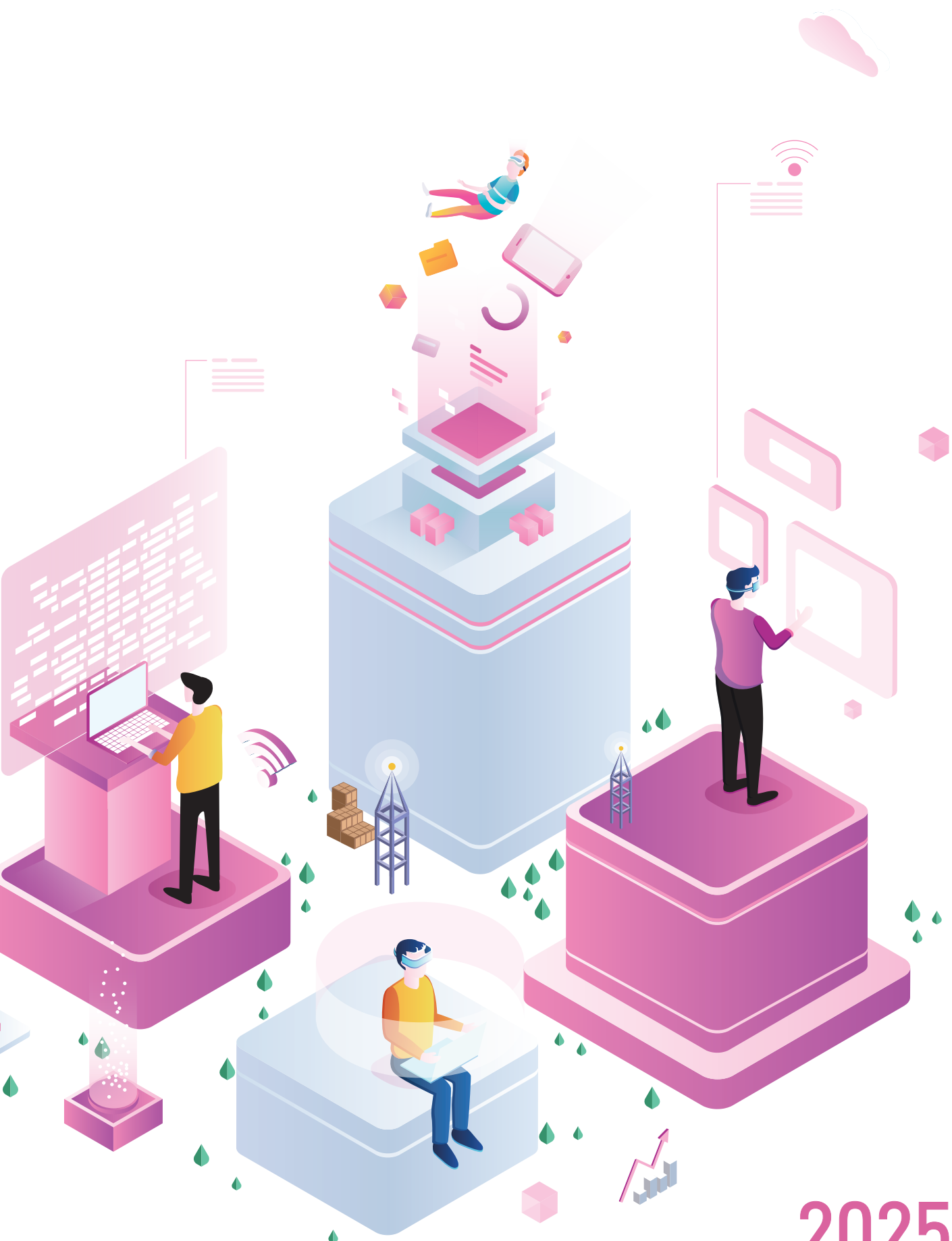
2025

Chapter 6: Other Emerging Technology Application

CHAPTER OVERVIEW

- Emerging technologies such as cloud computing, the IoT, and blockchain are deeply integrating with AI, collectively building a new infrastructure system for the digital transformation of SMEs. The global digital economy continues to grow, with cloud computing providing flexible computing support for SMEs, IoT technology enabling device connectivity and real-time data collection, and blockchain enhancing supply chain transparency through its traceability features. These technologies form a collaborative "cloud-network-edge-device" architecture, supporting innovative scenarios such as smart logistics and energy management. In developing countries, lightweight solutions like edge computing devices and 5G communication modules effectively lower the barriers to transformation through easy-to-deploy models, helping SMEs achieve significant improvements in profitability, customer reach, and operational efficiency.

- However, the adoption of emerging technologies in developing countries faces "last-mile" challenges. Inadequate infrastructure coverage remains the primary obstacle: unstable network connectivity and frequent power outages in remote areas make it difficult to sustain the operation of IoT devices and cloud platforms. The complexity of technology integration cannot be overlooked either: SMEs must simultaneously address issues such as multi-system compatibility, legacy equipment upgrades, and fragmented technical standards, while specialized technical services are scarce and costly. At a deeper level, there exists a digital capability gap: insufficient employee skills, limited management awareness, and a lack of full lifecycle technical support prolong the "transformation pain period." Additionally, cross-border technology cooperation faces barriers such as data localization regulations and divergent technical standards, hindering the realization of global technological dividends.

- This chapter features two typical practices that demonstrate the enabling role of ICT technologies in the digital transformation of SMEs from different dimensions. The Pakistan Entrepreneurship Connection Platform has built a digital cross-border cooperation ecosystem, providing SMEs with precise resource matching and market connectivity services, significantly enhancing their international competitiveness and innovation efficiency. SpaceIoT's satellite IoT monitoring solution utilizes space-based communication technology to overcome geographical limitations, achieving full-time data interaction for heavy machinery equipment in areas without terrestrial network coverage, delivering a low-cost, highly reliable technological pathway for the industrial monitoring sector. Together, these practices illustrate how emerging technologies, through differentiated application scenarios, can effectively address core pain points for SMEs in global collaboration and extreme environment operations, providing replicable practical models for digital transformation.

Pakistan Startup Connect (PSC) Portal – Enabling SME Digital Transformation through Cross-Border Collaboration

PRACTICE PROFILE

Small and Medium Enterprises (SMEs) in Pakistan face structural challenges such as limited access to finance, fragmented business networks, and minimal global visibility. These barriers hinder their ability to scale, innovate, and compete internationally. Recognizing this gap, Ignite launched the Pakistan Startup Connect (PSC) Portal, a digital matchmaking and collaboration platform designed to integrate SMEs into global market.

The PSC portal leverages ICT to address SME bottlenecks by enabling cross-border networking, investor-startup matching, and business development opportunities. It connects startups and SMEs with corporates, investors, mentors, and policymakers, fostering a digitally integrated entrepreneurial ecosystem.

The portal's beneficiaries include hundreds of Pakistani startups and SMEs spanning ICT, fintech, health tech, edtech, e-commerce, and manufacturing. The implementation began in 2023, and has since expanded as a model for regional digital cooperation.

By enabling virtual collaboration and market access, PSC directly contributes to SMEs' digital transformation across areas such as market expansion, financing, and innovation-driven partnerships. The initiative demonstrates strong scalability, as its ICT architecture allows replication in other sectors and international ecosystems.

DETAILED DESCRIPTION

Solution Implementation Details »

The PSC Portal was developed as a digital platform for startup ecosystem with the following technical and organizational components:

1. Digital Matchmaking Engine: AI-powered profiling of startups/SMEs based on industry, growth stage, and business needs. Algorithm matches them with relevant investors, corporates, or mentors.

2. Collaboration Portal: Provides virtual networking rooms, B2B/B2I meeting features, and event management. Enables digital pitching, cross-border deal-making, and partnership discussions.

3. Knowledge Hub: Centralized repository of market research, case studies, and innovation insights. Accessible resources for SMEs to enhance business strategies.

4. Cross-Border Integration: ICT linkages established with Chinese platforms and partner institutions. Facilitates access to international markets, especially for startups aiming at China-Pakistan Economic Corridor (CPEC) opportunities.

5. Analytics & Dashboard: Real-time tracking of SME engagements, deals, and collaborations. Policy insights for government agencies to monitor SME growth and ecosystem dynamics.

Implementation Resources:
- **Human Resources:** Ignite team, IT developers, SME relationship managers, innovation specialists.
- **Facilities:** Ignite headquarters, National Incubation Centers (NICs), cloud-hosted digital platform.
- **Data Sources:** Startup registration data, SME profiles, investor and corporate partner databases.
- **Technical Architecture:** Cloud-based hosting for scalability, secure authentication and data encryption for compliance, API integrations with external partners such as Securities and Exchange Commission Pakistan (SECP)
- **Implementation Period:** Pilot launched in 2023 → Ongoing expansion in 2025.
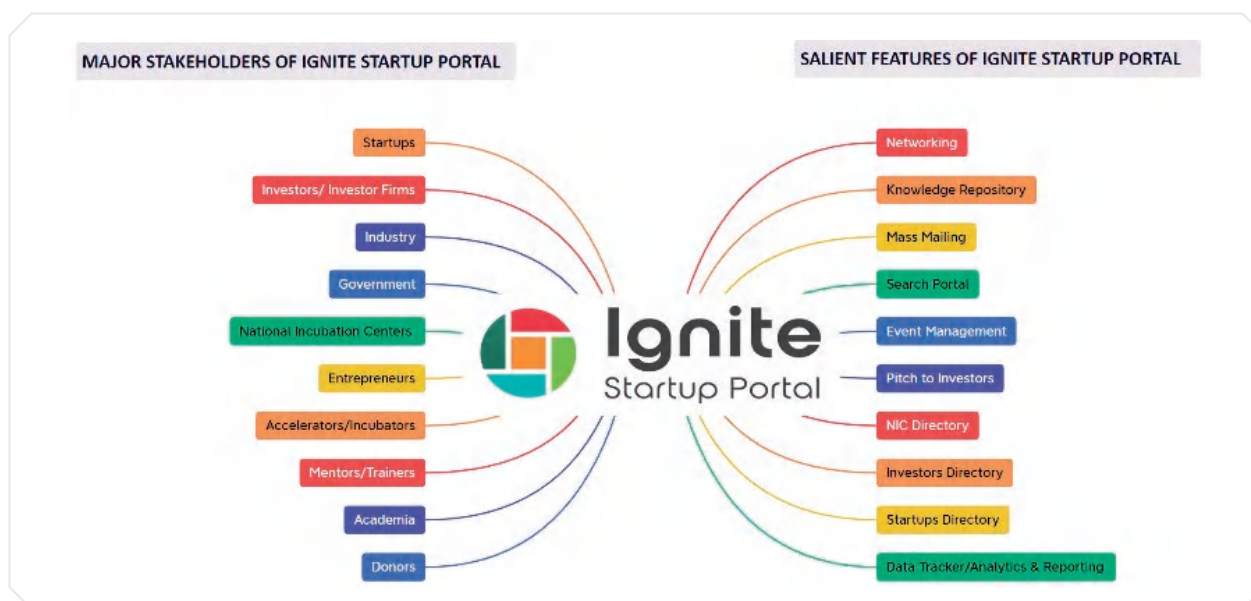
Outcomes Breakdown ❯❯

The PSC Portal has generated measurable economic and social impact:

Economic Impact:

- Over 2000 SMEs/startups digitally connected to investors and corporates.
- Financing mobilization: Multiple investment discussions initiated through the portal.
- **Market Access Expansion:** SMEs gained entry points to Gulf, European and American Markets and regional markets without high travel/transaction costs.
- Improved SME competitiveness through ICT-enabled deal-making.

Social Impact:

- Supports SDG 8 (Decent Work & Economic Growth) by enhancing SME employment and innovation.
- Contributes to SDG 9 (Industry, Innovation, and Infrastructure) through digital ecosystem building.
- Strengthens SDG 17 (Partnerships for the Goals) by linking Pakistan's SMEs with global stakeholders.
- Promotes inclusion by providing opportunities to women-led and youth-led startups, many from underserved regions.

The portal demonstrates how ICT-enabled platforms can reduce SME isolation, lower entry barriers, and foster cross-border collaboration, generating both economic growth and social cohesion.

Value Proposition »

PSC provides a scalable and replicable digital infrastructure for SME transformation. Its international scalability lies in its:

1. Generalization Across Industries – Can serve SMEs in ICT, agriculture, manufacturing, e-commerce, and services. Digital matchmaking logic adapts to different sectors' requirements.

2. Threshold Requirements – Basic cloud infrastructure and secure hosting. Moderate digital literacy for SMEs (with training support). Minimal hardware (laptops/smartphones with internet access).

3. Transformation ROI Period – Low-cost digital infrastructure means SMEs start seeing benefits (new leads, partnerships, funding) within 6–12 months. Government and private investors also gain measurable ecosystem insights quickly.

Replicability: The PSC model can be extended to other Belt & Road partner countries, creating a federated digital ecosystem of SMEs. Its architecture also allows vertical customization (e.g., fintech-only or Agritech-only matchmaking hubs).

IMPLEMENTING ENTITY PROFILE

Ignite – National Technology Fund »

Entity Type Public sector
Entrepreneurial Support Network

Core Business »

Ignite funds and supports technology-driven initiatives in Pakistan, including innovation hubs, startup incubators & accelerators, and digital platforms that empower SMEs and entrepreneurs. Its mission is to accelerate innovation, promote digital inclusion, and strengthen the startup ecosystem through strategic programs, funding, and partnerships.

Environmental and Heavy Machine Monitoring Based on Satellite Internet of Things

PRACTICE PROFILE

The environmental and heavy machinery equipment monitoring solution based on satellite Internet of Things fully utilizes the advantages of wide coverage, high real-time performance, and stable reliability of satellite Internet of Things communication. By installing satellite Internet of Things terminals on environmental monitoring equipment and heavy machinery equipment, the transmission link between ground environmental monitoring facilities and heavy machinery and satellite networks is connected, providing users with full-time, full range, and full domain coverage of integrated satellite communication services in the sky and earth, to achieve on-demand feedback of environmental and heavy machinery equipment operation and working condition data and issuance of control instructions.

DETAILED DESCRIPTION

Solution Implementation Details »

Satellite IoT terminal devices are connected to environmental monitoring equipment and vehicle mounted TBOX devices deployed on site through serial ports. Through this integrated solution, various types of data such as vehicle operation data and vehicle operation data can be collected and transmitted. The data transmission frequency during device operation is in the minute level, and the single transmission data can support 400-500 bytes, ensuring the timeliness and efficiency of data transmission while balancing transmission efficiency and energy consumption. Based on satellite IoT, by monitoring device status in real-time, enterprises can more effectively manage devices, optimize scheduling, reduce device waiting and idle time, and improve overall operational efficiency; At the same time, it can monitor the health status of equipment, predict potential failures and maintenance needs, help enterprises implement preventive maintenance, extend equipment life, reduce unexpected downtime, effectively reduce equipment maintenance and

operation costs, and minimize potential risks and losses caused by equipment failures; In addition, satellite IoT can help enterprises accurately locate devices, effectively manage assets, and prevent device loss or theft. Therefore, adopting satellite IoT can not only effectively solve the pain points of environmental monitoring and heavy machinery equipment monitoring data transmission, but also help improve the operational efficiency, safety, reliability, and economy of equipment. It is of great significance for achieving intelligent and refined management of environmental monitoring and heavy machinery equipment, and improving the management and operational efficiency of enterprises.

Solution and Architecture

Application Scenarios

System Architecture

Communication Satellite

Satellite Network

Satellite Network

Ground Station

Satellite IoT Terminal

Terrestrial Network

Business Application System

Fertilizer Spreaders	Dredging Machines	Logging Equipment
40K Bytes per time, once per day	5K Bytes per time, once per day	20K Bytes per time, once per day

Satellite IoT Monitoring Data

Fertilization
Depth
Frequency
Position

Operation
Time
Progress
Pass Rate

Operation
Position
Fuel Consumption
Operating Time
Equipment Status
Fault Alarm

Logging
Quality
Volume

Operation
Area
Time
Progress
Frequency

Fully leveraging the advantages of satellite communications, satellite IoT terminals are installed on **fertilizer spreaders**, **dredging machines**, and **logging equipment** to establish a seamless transmission link between ground facilities and the satellite network. This enables users to access **all-time, all-process, and all-area integrated satellite communication services**, allowing real-time, on-demand transmission of operational and condition data from ground machinery.

Outcomes Breakdown ≫

The application solution for environmental and heavy machinery equipment monitoring based on satellite IoT fully integrates the advantages of environmental monitoring, heavy machinery equipment monitoring, and satellite IoT communication technology. It can provide continuous, real-time, and high-precision uplink transmission and downlink command interaction capabilities for environmental and heavy machinery equipment monitoring data worldwide, which is of great significance for improving the efficiency of environmental and heavy machinery equipment operation monitoring, promoting the operational efficiency of environmental and heavy machinery equipment, and asset management.

Value Proposition »

Satellite IoT technology has brought new ideas to the monitoring and management of the environment and heavy machinery equipment, providing effective solutions for data transmission in scenarios without ground network coverage. It can perfectly meet the needs of large-scale, high-frequency, real-time, and long-term equipment monitoring and bidirectional data transmission, enhance the monitoring and management capabilities of environmental and heavy machinery equipment in complex environments, and is a necessary requirement for future environmental and heavy machinery equipment monitoring applications. It has broad application markets and promotion value.

IMPLEMENTING ENTITY PROFILE

SpaceIoT(Wuxi) Aerospace Co., Ltd. »

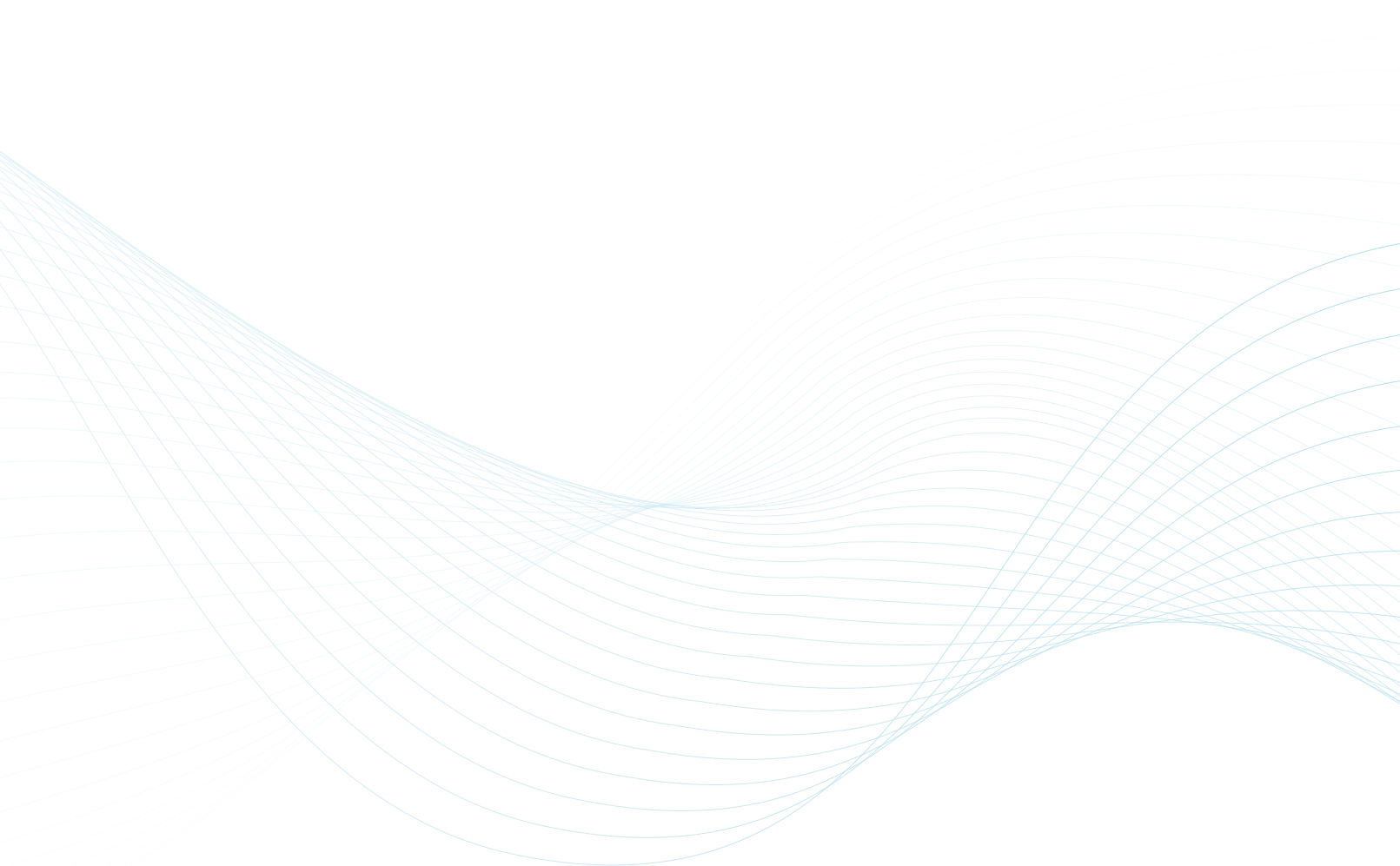**Entity Type**   Startups and SMEs

物宇星联
WuyuSatlink

Core Business »

SpaceIoT(Wuxi) Aerospace Co., Ltd. was established in September 2021. It is a provincial-level specialized and innovative enterprise and a national level high-tech enterprise specializing in the field of satellite IoT. The company focuses on the research and application of 5G NTN (non terrestrial network) technology in the next generation communication system, relying on its self-developed 5G NTN satellite IoT communication protocol and satellite IoT terminals, to create a global communication network that integrates heaven and earth, and provide cost-effective one-stop satellite IoT solutions for global customers.

CONCLUSION

Through a systematic review and in-depth analysis of typical practices from around the world, this collection presents a practical landscape of ICT-enabled digital transformation for SMEs. Spanning sectors from manufacturing and services to agriculture, these practices validate the core role of ICT technologies in enhancing efficiency, optimizing costs, and creating value for SMEs. They demonstrate adaptable pathways tailored to the diverse resource bases and developmental stages of SMEs worldwide, offering valuable references for their digital transformation.