

From Awareness to Impact: A Structural Equation Modeling Approach to the Digitalization Of SMEs in the Andaman and Nicobar Islands

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ABSTRACT

The Andaman and Nicobar Islands in India, with their unique geographical isolation and limited infrastructure, present a distinct environment for Small and Medium-sized Enterprises. In such a context, digitalization has the potential to transform how local businesses operate, connect with markets, and manage resources. This study aims to explore the determinants of the impact of digitalization on SMEs operating in this ecologically sensitive and logistically challenging region. A structured questionnaire was developed with five core dimensions: awareness, training, usage, investment, and impact. Primary data was collected from 53 registered SMEs during May 2025. This study used Descriptive Statistics, ANOVA, and Correlation to get insights about the data. Further, using Structural Equation Modeling (SEM), this study validated the relationships among constructs and assessed the influence of awareness, training, usage, and investment on the impact. The SEM results reveal statistically significant relationships, indicating that awareness and training positively influence digital usage, training drives usage, digital usage significantly boosts investment, and investment strongly impacts overall digital outcomes for SMEs. The study underscores the need for structured training programs, policy support, and accessible digital infrastructure to enhance the digital maturity of island-based SMEs.

Keywords: A&N Islands, Digitalization, Digital Impact, SEM, SMEs

JEL Code: R11, M15, C38

1. INTRODUCTION

SMEs in India are one of the main drivers of inclusive development. However, these enterprises are typically affected by structural constraints, weak access to finance, and limited market reach, hindering their development potential (Mehta & Bhandari, 2023).

The rapidly evolving digital technology offers small and medium-sized enterprises (SMEs) a strategic opportunity to enhance their operational efficiency, cost efficiency, and access to new markets. Digital technologies such as e-commerce sites, online payment platforms, customer relationship management software, and cloud computing have emerged as key drivers of competitiveness and viability (Singh, 2023). The use of digital technology among SMEs continues to be scattered, particularly in geographically remote regions with limited infrastructure and low digital literacy (Goundar & Narayan, 2023).



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Despite international efforts at digital inclusion, few empirical studies of the digital revolution economy SMEs have been conducted, especially within the Indian context. The Andaman and Nicobar Islands, with their distinct socio-economic structure and geographical remoteness, offer a practical case study of how indigenous SMEs embrace, adapt, or reject digital technology. These enterprises, from the tourism, fishing, and handicraft sectors, stand to gain significantly from digital integration, awareness, and training; nonetheless, they face many challenges owing to the infrastructure deficits and policy inattention (Ragulina, 2024; Goundar & Narayan, 2023).

This research attempts to fill this gap by critically examining the impact of digitalization on the Andaman and Nicobar Islands SMEs. The objective is to evaluate the degree of digital adoption, awareness, and training provided, determine digital change drivers and barriers, and provide context-specific recommendations to policymakers and practitioners who want to trigger sustainable SME growth in remote island areas.

1.1. Research Problem

SMEs in the Andaman and Nicobar Islands face limited access to digital infrastructure, skills, and support, hindering their optimal adoption of digital technologies. Existing research lacks region-specific insights, creating a gap in understanding how digitalization impacts these remote enterprises and what strategies can effectively support their digital transformation.

1.2. Research Objective

- To determine the current level of awareness, access, and utilization of digital technologies by SMEs in the Andaman and Nicobar Islands.
- To study the nature of digital platforms and tools.
- To identify the key barriers to digital adoption among SMEs in the region.
- To assess the perceived and actual impact of digitalization on SME performance.

2. LITERATURE REVIEW

Digital Awareness

Studies consistently report increasing awareness among SMEs regarding the value of digital tools and platforms, driven largely by exposure to global markets and competitive pressures (Müller, Buliga, & Voigt, 2018). However, the literature also highlights that heightened awareness does not automatically translate into adoption, as many SMEs struggle with technological complexity and lack internal capabilities required for implementation (Zhou, Lu, & Wang, 2021).

Training and Digital Skill Development

Digital literacy and structured training are identified as core enablers of digital transformation. SMEs in developing and remote regions often face substantial skill deficits that limit their ability to deploy and maintain digital systems (Khin & Ho, 2019). The absence of continuous skill development and knowledge-sharing mechanisms further constrains effective adoption (Bican & Brem, 2020). OECD (2020) emphasizes the need for ecosystem-level skill development, while research stresses that digital readiness depends not only on technology but also on human capital quality (Li, Su, & Liu, 2020).

Digital Usage and Integration

The depth of digital usage among SMEs varies considerably. Some firms integrate advanced digital tools for operations, customer management, and supply chain coordination, while many remain confined to basic applications such as email or simple digital marketing (Ng & Wakenshaw, 2017). Usage patterns often correlate with firm size, sector, and leadership orientation toward innovation (Nambisan, Wright, & Feldman, 2019). Environmental factors—such as infrastructure reliability, regulatory support, and access to technical assistance—also shape the extent to which SMEs embed digital tools into core operational activities (OECD, 2021).

Investment in Digital Technologies

Financial constraints remain one of the most significant barriers to digital adoption. Digitalization typically requires ongoing investment in both tangible and intangible assets (Bharadwaj et al., 2013). SMEs, particularly in underserved regions, often perceive digital transformation as capital-intensive and are hesitant to invest without assured returns (Li et al., 2020). To address these challenges, scholars advocate for inclusive financing models, including subsidies, microfinance, and public-private partnerships, to enhance SMEs' investment capacity (Kraus et al., 2021).

Impact on Business Performance

The impact of digitalization on SME performance is well-documented in empirical research. Digital transformation has been shown to improve productivity, operational efficiency, and market competitiveness (Verhoef et al., 2021). Digital tools also enable SMEs to reach wider markets, personalize customer experiences, and streamline processes. However, scholars caution that these benefits are contingent upon the strategic alignment of digital initiatives with broader business goals; without such alignment, digitalization may increase operational complexity rather than enhance performance (Henriette, Feki, & Boughzala, 2015).

3. METHODOLOGY

- This study adopts descriptive and quantitative approaches to understand digitalization's impact on SMEs comprehensively.
- The study area selected for this study is the Andaman and Nicobar Islands.
- The target population includes the registered SMEs operating in key sectors such as tourism, agriculture, fisheries, services, fitness, printing, retail, handicrafts, and others across the Andaman and Nicobar Islands.
- A **convenience sampling technique** was used, which ensured representation across sectors and island districts.
- A sample size of **53 SMEs** was taken for the survey.
- **Primary Data:**
 - **Structured Questionnaire:** A survey instrument was designed to collect data divided into sections like Awareness, Tools used, training provided, Investment made, Usage of Digitalization, and Impact of Digitalization on their SMEs.
- **Secondary Data:** Secondary sources such as government reports, MSME databases, policy documents, and prior research studies will support context and triangulate findings.

4. Data Analysis:

- Descriptive Statistics:
 - Summarized SMEs Profile and analyzed using frequencies and percentages.
 - Continuous variables (e.g., age, employee size, and turnover) were analyzed using means and standard deviations.
- Correlation Analysis:
 - Used Pearson's correlation to examine relationships between digitalization and performance metrics.
- ANOVA Analysis:
 - One-way ANOVA tested differences in digitalization across:
 - Sector-wise: Agriculture, Manufacturing, and Services.
 - Age-wise: Firms established between 1990 and 2024.
 - Ownership type: Sole proprietorships, partnerships, cooperatives/SHGs, and private companies.
 - Region-wise: Regional digital readiness varied (South Andaman, North and Middle Andaman, and Nicobar).
 - Gender-wise: Male and Female owners.
 - Employment-wise: Number of employees.
 - Turnover-wise
- SEM-PLS Modeling: Employed PLS-SEM using SmartPLS4 to test hypothesized relationships.
 - Reliability: Cronbach's α & composite reliability > 0.70.
 - Convergent validity: AVE > 0.50.
 - Path Co-efficient

5. RESULTS/ANALYSIS AND DISCUSSION:

5.1. Descriptive Statistics of Mean Scores of Variables

Variable	N	Min	Max	Mean	SD
Awareness & Tools	53	1.60	5.00	3.6717	.80775
Training	53	1.50	4.75	3.2720	.76641
Investment	53	1.40	5.00	3.3509	.78241
Usage	53	1.80	5.00	3.5660	.78322
Impact	53	1.40	5.00	3.4642	.76839

Interpretation: In Table 1, Descriptive statistics for the key study variables from the 53 respondents are as follows: Awareness and Tools were observed to be the highest in mean score, N = 53, M = 3.67, SD = 0.81,

followed by Usage, $M = 3.57$, $SD = 0.78$, and Impact, $M = 3.46$, $SD = 0.77$. Investment yielded a moderate mean level, $M = 3.35$, $SD = 0.78$, while Training yielded the lowest mean score, $M = 3.27$, $SD = 0.77$. The minimum and maximum scores for most variables ranged from 1.40 to 5.00, reflecting reasonable variability. Overall, findings have revealed a relatively high level of awareness and tool usage being reported by the respondents, but training seems to be the relatively weaker link.

5.2. CORRELATION

Table 2					
Variables	A&T	Training	Investment	Usage	Impact
1. A&T	—				
2. Training	.40**	—			
3. Investment	.57**	.58**	—		
4. Usage	.54**	.55**	.80**	—	
5. Impact	.43**	.48**	.75**	.79**	—

Interpretation: Table 2 displays The Pearson's product-moment correlation coefficients were calculated to study the relationships among A&T, Training, Investment, Usage, and Impact. The result of the analysis showed that Awareness and Tools is positively and significantly related to Training ($r = .40$, $p < .01$), Investment ($r = .57$, $p < .01$), Usage ($r = .54$, $p < .01$), and Impact ($r = .43$, $p < .01$). Training was also significantly positively related to Investment ($r = .58$, $p < .01$), Usage ($r = .55$, $p < .01$), and Impact ($r = .48$, $p < .01$). Investment and Usage were highly associated, at $r = .80$, $p < .01$, and Investment and Impact were highly associated, at $r = .75$, $p < .01$. Usage and Impact also had a strong positive association with each other, at $r = .79$, $p < .01$. In general, the findings above point to a moderate-to-strong positive relationship between all the study variables, suggesting that higher awareness and training are associated with greater investment, increased usage, and higher perceived impact

5.3. ANOVA ANALYSIS

VARIABLES		AWARENESS AND TOOLS USED	TRAINING	USAGE	INVESTMENT	IMPACT
SECTOR_WISE	F	1.8	1.37	2.17	5.86	2.08
	Sig.	0.18	0.27	0.13	.01*	0.14
AGE_WISE	F	1.56	0.09	2.29	1.85	0.2
	Sig.	0.22	0.76	0.14	0.18	0.66
OWN_TYPE	F	2.58	0.74	2.83	2.15	0.96
	Sig.	0.07	0.53	.05*	0.11	0.42
REGION_WISE	F	1.9	1.67	4.5	4.46	5.12
	Sig.	0.16	0.2	.02*	.02*	.01**
OWN-GENDER	F	1.86	0.76	0.49	0.11	0.61
	Sig.	0.15	0.52	0.69	0.96	0.61
EMP_WISE	F	1.27	1.86	0.82	0.87	0.73
	Sig.	0.29	0.15	0.49	0.47	0.54
TURNOVER-WISE	F	0.82	0.44	0.48	0.25	0.03
	Sig.	0.49	0.72	0.7	0.86	0.99

Interpretation: The one-way ANOVA results showed that investment was significantly different across sectors, $F = 5.86$, $p = .01$, while usage was significantly different across ownership type, $F = 2.83$, $p = .05$. Region-wise, there were significant differences for usage, $F = 4.50$, $p = .02$, investment, $F = 4.46$, $p = .02$, and impact, $F = 5.12$, $p = .01$, suggesting that the geographical context is important in shaping the adoption and

outcomes. In contrast, age, owner gender, number of employees, and turnover did not differ significantly across any of the study variables, all $p > .05$, suggesting that organizational and contextual factors rather than demographic characteristics are the major determinants of awareness, training, usage, investment, and perceived impact.

5.4. SEM MODELLING:

5.4.1. Construct Reliability and Validity:

Table 4				
Construct Reliability and Validity				
	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
A&T	0.827	0.947	0.882	0.579
Impact	0.811	0.941	0.883	0.605
Investment	0.827	0.903	0.883	0.562
Training	0.777	0.784	0.85	0.535
Usage	0.682	0.891	0.774	0.422

Interpretation: The measurement model showed acceptable reliability, with Cronbach's alpha (0.682–0.827) and composite reliability ($\rho_c = 0.774$ –0.883) exceeding recommended thresholds for most constructs (Hair et al., 2019). AVE values ranged from 0.422 to 0.605, indicating adequate convergent validity, except for **Usage** (AVE = 0.422), which fell slightly below the 0.50 benchmark (Fornell & Larcker, 1981). This suggests a potential need to refine the indicators for the Usage construct.

Table 5			
Path Co-efficient			
		T statistics	P values
A&T -> Usage		3.604	0
Investment -> Impact		13.081	0
Training -> Usage		3.355	0.001
Usage -> Investment		25.564	0

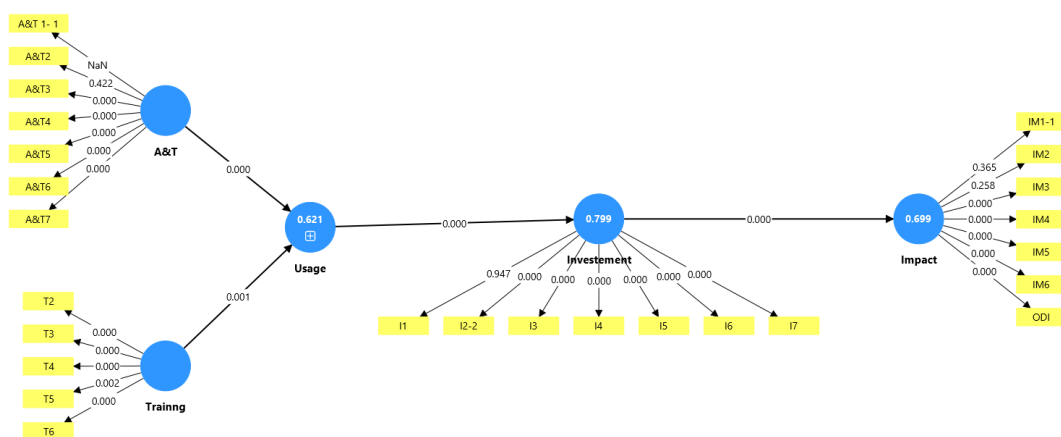


Figure: 1

Interpretation: Fig. 1 presents the path coefficients, and the results support all proposed hypotheses:

- H1: Awareness & Tools → Usage
- H2: Training → Usage
- H3: Usage → Investment

- H4: Investment → Impact

Path analysis (see Table 5) showed that all hypothesized relationships were significant. Awareness ($\beta = 0.468$, $p < .001$) and training ($\beta = 0.421$, $p = .001$) positively influenced usage. Usage strongly predicted Investment ($\beta = 0.894$, $p < .001$), which in turn significantly impacted business outcomes ($\beta = 0.836$, $p < .001$). These results confirm the sequential influence of awareness, training, and Usage on Investment and impact.

5.5. Results and Discussions:

- **Geographical and Sectoral Concentration** Most surveyed SMEs (83.7%) are located in South Andaman, highlighting a geographical concentration of business activity and access to relatively better infrastructure. Few SMEs operate in North and Middle Andaman (6.1%) and Nicobar (10.2%), indicating limited business penetration in remote areas. Sector-wise, service-oriented enterprises (46.9%) and manufacturing units (40.8%) dominate the SME landscape. In comparison, agriculture-based SMEs account for only 12.2%, reflecting a shift towards tertiary and secondary sectors in the islands' economy.
- **Ownership Demographics and Business Type:** Most SMEs are relatively young, with 79.6% established between 2000 and 2025, indicating a growing entrepreneurial trend in the 21st century. In terms of ownership, male entrepreneurs dominate (73.5%), while female-owned SMEs remain underrepresented (6.1%), with joint ownership (20.4%) suggesting some level of collaborative or family-run business ventures. Sole proprietorship is the most common business model (69.4%), followed by partnerships (22.4%), indicating a preference for simpler organizational structures with limited regulatory burdens.
- **Business Scale and Financial Strength:** A significant portion of SMEs are micro and small in scale, with 61.2% employing fewer than 20 people and 49% reporting annual turnover below ₹1 crore, reflecting the typical size of island-based enterprises. Only 2.0% report a turnover above ₹50 crore, and 8.2% have over 100 employees, suggesting a small but present group of high-performing or mid-sized firms. This distribution underscores the need for tailored digital strategies based on enterprise size and financial capacity.
- **High Awareness, Moderate Usage, and Lower Training & Investment:** SMEs reported the highest mean score for Awareness & Tools ($M = 3.67$), followed by **Usage** ($M = 3.56$), suggesting strong familiarity and engagement with digital tools. Lower mean scores for Training ($M = 3.2$) and Investment ($M = 3.3$) reflect gaps in skill development and financial commitment to digitalization.
- **All Constructs Positively Correlated:** Significant positive correlations ($p < .01$) were observed among all variables. Investment strongly correlates with Usage ($r = .805$) and Impact ($r = .752$), indicating that financial input is central in generating digital outcomes. Training was moderately correlated with **Usage** ($r = .578$) and Impact ($r = .484$), highlighting its supportive role in enhancing performance.

6. Demographic Influence: Sector and Region Matter

- **ANOVA analysis** revealed significant differences in:
 - Investment by sector ($F = 5.86$, $p = .01$) and region ($F = 4.46$, $p = .02$).
 - Usage by region ($F = 4.50$, $p = .02$).
 - Impact by region ($F = 5.12$, $p = .01$).

- **Measurement Model: Reliability Established, Some Validity Issues:** All constructs showed acceptable reliability (Cronbach's α = 0.682–0.827; Composite Reliability = 0.774–0.883). Convergent validity was satisfactory for all constructs except usage, which had a low AVE (0.422), slightly below the recommended 0.50 (Fornell & Larcker, 1981). This suggests that Usage indicators may require refinement to improve construct validity.
- **Structural Model: All Hypotheses Supported:** Path analysis confirmed all hypothesized relationships: These paths validate a sequential model of digital adoption, where awareness and training lead to increased usage, which prompts Investment and produces a measurable impact.
- **The Role of Usage as a Key Driver:** Usage is a central mediator between training/awareness, investment, and ultimately impact. SMEs actively using digital tools are more likely to invest further, reinforcing a cycle of digital maturity.

6.1. SUGGESTIONS:

Based on the findings, SMEs should prioritize systematic and ongoing training programs that close the gap between high awareness and lower development of skills. Sector-specific and regionally tailored mechanisms for financial support will ensure digital investments translate into actual usage and measurable business impact. Policymakers and support agencies have a role in enhancing regional digital infrastructure and localized technical support, to reduce geographic disparities in adoption. Ownership practices need to be aligned with clear strategies on digital issues and performance monitoring systems to progress consistency in usage. Regularly connecting digital investments with performance outcomes will ensure better accountability and improvement in resource utilization. Lastly, forming knowledge-sharing platforms and easy-to-understand digital roadmaps will help the firms ensure that basic awareness is converted into effective and sustainable implementation.

7. CONCLUSION AND IMPLICATIONS

This research critically analyzes the digitalization process of SMEs in the Andaman and Nicobar Islands, focusing on the interconnected dynamics of awareness, training, usage, Investment, and impact. The study findings conclude that SMEs reflect a relatively high rate of awareness and tool usage, which signifies readiness to embrace digital technologies. Lower rates of training and Investment, however, reflect significant impediments that restrict the full potential of digital change.

The significant and positive relationships between awareness, usage, training, Investment, and impact emphasize digital capability development's significance in encouraging proactive technology adoption. The significant positive impact of Usage on Investment and, in turn, impact also verifies that digital usage induces financial Investment and enhanced business performance. This causal mechanism is consistent with prevailing digital adoption models, verifying that informed and capable SMEs are more likely to invest with quantifiable outcomes.

The study also reveals important regional and sectoral differences, indicating that geographic and context-specific factors influence digitalization outcomes. The differences entail context-specific strategies and localized interventions to address the digital divide and stimulate inclusive growth across all SME segments.

The study provides valuable lessons to policymakers, practitioners, and researchers by emphasizing the importance of properly integrated responses involving awareness campaigns, capacity building, and financial incentives. Comprehensively addressing these issues, the stakeholders can create a more favorable

environment that is more conducive to the digital transformation of the SMEs and, hence, sustainable economic growth in the special case of the Andaman and Nicobar Islands.

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