Original Article
ISSN (Online): 2582-7472

ShodhKosh: Journal of Visual and Performing Arts
Special Issue on Contemporary Perspectives in Science, Technology, Humanities and Management 7(7s)

UNDERSTANDING BARRIERS TO DESIGN THINKING ADOPTION IN INDIAN MANUFACTURING MSMES: EVIDENCE FROM A SEQUENTIAL MIXED-METHODS STUDY

Meraj Alam Idrisi [1], Ranganath M. Singari [2]

[1] Department of Design, Delhi Technological University, Delhi 110042, India
[2] Department of Design, Delhi Technological University, Delhi 110042, India

Received 23 February 2026
Accepted 28 April 2026
Published 21 May 2026

Corresponding Author
Meraj Alam Idrisi,
merajaidrisi@gmail.com

DOI
10.29121/shodhkosh.v7.i7s.2026.8222

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ABSTRACT

The formulation of Human centred Innovation, Design Thinking (DT) is gaining traction as a key methodology for innovation, but its implementation within the Indian manufacturing Micro, Small, and Medium Enterprise (MSME) sector, which contributes about 45% of the manufacturing output in the country, is limited and patchy. In this paper, the multi-level barriers for DT adoption in Indian manufacturing MSMEs are empirically identified and quantified, and the barriers are theorised. A sequential explanatory mixed-methods design was employed: a 47-item structured survey of 312 MSMEs across five major industrial clusters was followed by 28 in-depth interviews. Exploratory and Confirmatory Factor Analysis identified seven barrier dimensions explaining 68.4% of variance. Covariance-based Structural Equation Modelling (n = 312; CFI = 0.94; RMSEA = 0.063; R^2 = 0.58) supported all seven hypotheses. Financial Constraints (β = −0.41) and Awareness Deficit (β = −0.38) emerged as the strongest inhibitors, while Policy Ecosystem quality positively moderated the readiness–adoption pathway (β = +0.31). Qualitative themes-the "design blindspot," the "thin-margin trap," and the policy "last-mile" gap-explain the cognitive, financial, and institutional mechanisms underlying these effects. The study contributes (a) the first statistically validated barrier taxonomy for DT adoption in Indian manufacturing MSMEs, (b) a three-tier (micro–meso–macro) Layered Barrier Model integrating four theoretical lenses (Diffusion of Innovations, TAM, RBV, Institutional Theory), and (c) a five-stage adoption roadmap with a matching policy-intervention matrix for emerging-economy SME ecosystems.

Keywords: Design Thinking Adoption, Barriers, Indian MSMES, Manufacturing, Mixed-Methods, Structural Equation Modelling, Emerging Economy, Innovation Capability, Design-Led Innovation, Industry 5.0

1. INTRODUCTION

India's manufacturing sector is at a critical inflection point. Under the Make in India and Atmanirbhar Bharat initiatives, manufacturing MSMEs-which constitute over 94% of industrial units, employ approximately 110 million workers, and contribute about 45% of total manufacturing output (Ministry of MSME, 2023)-are expected to serve as the engine of industrial transformation, export competitiveness, and inclusive employment generation. Yet a persistent innovation deficit constrains MSME competitiveness in domestic and global markets, with R&D intensity in the sector estimated at below 1% of turnover, far behind the 3–5% benchmark of high-performing global peers (OECD, 2023; Bahl et al., 2021). With the emergence of Industry 5.0—characterized by human–machine collaboration and user-centred value creation (Xu et al., 2021; Maddikunta et al., 2022), the need for a design-led innovation capability in MSMEs is even greater.

The Design Thinking (DT) methodology—a problem-solving process focused on human-centred, iterative testing, prototyping, ideation and empathy, has been applied and demonstrated in various industries to create product innovation, process improvement and customer value creation (Brown, 2008; IDEO, 2015; Liedtka, 2018). Preliminary studies in Europe and North America demonstrate that DT improves SME innovation performance, speed to market, and product–market fit (Carlgren et al., 2016; Knight et al., 2020; Klenner et al., 2022). However, anecdotal, fragmented and weakly documented in literature is DT adoption in Indian MSMEs, in the span of ten years of policies like Design Clinic Scheme (NID, 2010; 2019).

Why is it that Indian manufacturing MSMEs do not embrace Design Thinking, despite its potential and policy intentions is a research question both theologically and practically urgent. Past research in India has been descriptive in nature, single case or cluster with less statistical generalisation or comparative data between clusters (Mehta, 2014; Bahl et al., 2021). Section 2 builds upon the theoretical framework, the research hypotheses, and literature gap analysis (Table 1) that places this present study's contribution.

1.1. RESEARCH QUESTIONS

This study is guided by the following research questions:

1) RQ1. What are the primary barriers preventing Indian manufacturing MSMEs from adopting Design Thinking?
2) RQ2. How do these barriers interact in shaping firms' DT adoption intention?
3) RQ3. How do contextual factors-firm size, industrial cluster, and owner education-moderate the barrier–adoption relationship?
4) RQ4. Which policy and practitioner interventions are most effective in reducing these barriers?

1.2. SIGNIFICANCE AND CONTRIBUTIONS

This paper makes four primary contributions. First, it provides the first large-scale, multi-cluster empirical examination of DT adoption barriers specifically in Indian manufacturing MSMEs-a context largely invisible in the international design-management literature. Second, it advances a statistically validated barrier taxonomy through rigorous multivariate analysis, moving beyond descriptive inventories. Third, it integrates findings into a three-tier Layered Barrier Model that distinguishes firm-internal (micro), cluster (meso), and policy-system (macro) barriers, offering theoretical clarity and a framework for multi-level intervention design. Fourth, it develops a sequential adoption roadmap (Figure 8) and policy-intervention matrix (Table 9) that operationalise the empirical findings for MSME owners, design educators, and policymakers.

2. THEORETICAL BACKGROUND, LITERATURE GAP, AND HYPOTHESIS DEVELOPMENT

2.1. COMPARATIVE LITERATURE ANALYSIS AND RESEARCH GAP

Table 1 synthesises the empirical literature on DT and innovation adoption in SMEs and emerging economies, comparing context, methodology, key findings, and limitations. The synthesis surfaces three persistent gaps that the present study addresses: (i) the absence of multi-cluster, statistically validated studies in the Indian manufacturing MSME context; (ii) the dominance of single-method designs that obscure context-specific causal mechanisms; and (iii) the limited integration of multiple theoretical lenses needed to capture the multi-level nature of adoption barriers in emerging-economy ecosystems.

Table 1

Table 1 Comparative Literature Analysis and Research Gap Synthesis.

Author(s)	Context	Method	Key Findings	Limitation	Gap Addressed Here

Müller & Thoring (2012)	European SMEs	Conceptual / case	DT enhances SME innovation; identifies DT vs Lean Startup overlap	Conceptual; no statistical validation	Provides SEM-based effect-size estimates for an Indian MSME sample
Liedtka (2018)	Multinational firms (mainly Global North)	Case-based theory building	DT works because it manages cognitive biases of innovation	Large-firm bias; limited SME generalisation	Tests DT adoption mechanisms in resource-constrained MSMEs
Carlgren et al. (2016)	Cross-sector European firms	Qualitative interviews	DT framed through five thematic areas in practice	Lacks emerging-economy data	Adds empirical evidence from Indian manufacturing clusters
Bahl et al. (2021)	Indian industries (general review)	Narrative review	DT applications described across sectors	No primary data; no taxonomy	Provides validated seven-factor taxonomy with EFA + CFA
Singh & Kumar (2020)	Indian SMEs (single state)	Survey, descriptive	Awareness and finance highlighted as barriers	Single-state; no SEM; no theory integration	Multi-cluster SEM with theory-grounded hypotheses
Knight et al. (2020)	Strategy-DT integration	Conceptual + cases	DT bridges intuition and analysis in strategy	Western, large-firm orientation	Operationalises DT for emerging-economy MSME strategy
Klenner et al. (2022)	Innovation management literature	Systematic review	DT capability differs by organisational maturity	No primary data; no MSME focus	Empirically maps DT adoption gaps by firm size
Roy & Modak (2026)	Indian manufacturing (ISM-based)	Interpretive Structural Modelling	Identifies DT enabler hierarchy	Small expert panel; no firm-level survey	Provides large-sample firm-level barrier evidence
Khurana et al. (2021)	Indian manufacturing enterprises	Survey, sustainability focus	Innovation–sustainability integration challenges	Sustainability focus; not DT-specific	Extends to DT methodology adoption specifically
Present Study	**Indian manufacturing MSMEs · 5 clusters**	**Mixed-methods · EFA + CFA + SEM + MGA + qualitative**	**Seven-factor barrier taxonomy; Layered Model; policy matrix**	**-**	**Multi-cluster, theory-integrated, SEM-validated**

2.2. INTEGRATED THEORETICAL FRAMEWORK

This study integrates four complementary theoretical lenses to frame DT adoption in MSMEs. Rogers's (1983) Diffusion of Innovations explains how knowledge, persuasion, and decision-making determine the social diffusion of an innovation. Davis's (1989) Technology Acceptance Model-extended by Venkatesh et al. (2003) into UTAUT-links perceived usefulness, ease of use, and facilitating conditions to behavioural intention. Barney's (1991) Resource-Based View frames financial, human, and infrastructural endowments as preconditions for innovation capability. DiMaggio and Powell's (1983) Institutional Theory frames policy ecosystems, industry associations, and normative pressures as enabling or constraining structures.

These theories are complementary rather than substitutive: Diffusion of Innovations explains the awareness-and-decision pathway (most relevant to B2 and B4); RBV explains internal capability and slack constraints (B1, B3, B5); TAM/UTAUT explains behavioural intention as a function of perceived usefulness and facilitating conditions (the DV and B7); and Institutional Theory explains the macro ecosystem and its moderating role on individual firm choice (B6, H6). Integrating these lenses enables a multi-level understanding of DT adoption barriers that no single theory affords.

2.3. RESEARCH MODEL AND VARIABLE JUSTIFICATION

The dependent variable, DT Adoption Intention, was selected over actual adoption for two reasons: (a) actual adoption in MSMEs is rare and exhibits low variance in the sample (only 8.3% actively practising), making intention the more sensitive outcome; and (b) adoption-intention has well-established validity as a behavioural antecedent in technology-adoption research (Venkatesh et al., 2003). The six direct-effect independent variables (B1–B5 and B7) were selected because each corresponds to a distinct theoretical mechanism-resource scarcity, knowledge gap, human capital, cultural fit, technical infrastructure, and accountability-that the literature has independently linked to innovation adoption. Policy Ecosystem (B6) is modelled as a moderator rather than a direct effect because institutional structures shape the conditions under which firm-level efforts translate into adoption, rather than acting on intention directly (DiMaggio & Powell, 1983; Scott, 2014). All directional hypotheses are negative for B1–B5 and B7 (barriers inhibit adoption) and positive for the H6 moderation (stronger ecosystems amplify readiness).

2.4. HYPOTHESIS DEVELOPMENT

2.4.1. FINANCIAL AND RESOURCE CONSTRAINTS (H1)

The literature in SMEs shows that resource constraints are the most recurring factor that hinders the process of innovation adoption in SMEs (Hausman, 2005; Thong, 1999; Chege & Wang, 2020; Klenner et al., 2022). There are financial constraints in DT such as no funding for design training, no design professionals, no funding for prototyping materials, or no consultants. As reported by Bloom et al. (2013), scarcity of resources in management systems is a systematic problem affecting manufacturing companies in India, which is a direct constraint on the investment in innovation. For RBV, the lack of slack is a constraint on experimentation (Nohria & Gulati, 1996).

H1: Financial and resource constraints are negatively associated with Design Thinking adoption intention in manufacturing MSMEs.

2.4.2. AWARENESS AND KNOWLEDGE DEFICIT (H2)

Adoption of innovation requires knowledge of the innovation (Rogers, 1983). Awareness of DT as a business problem-solving tool apart from aesthetic styling is limited even in the context of MSMEs in India, especially for the first-generation entrepreneurs and traditional manufacturing communities (Mehta, 2014; Singh & Kumar, 2020; Khurana et al., 2021; Garg & Agarwal, 2023). This is further exacerbated by lack of access to design education and paucity of case literature on DT relevant to MSME in vernacular languages.

H2: Awareness and knowledge deficit is negatively associated with Design Thinking adoption intention.

2.4.3. SKILLED TALENT SHORTAGE (H3)

Human-capital constraints in MSMEs include a lack of skilled design professionals. While large enterprises have the financial resources to employ specialist designers, MSMEs generally don't and also do not have the organisational frameworks to incorporate design as a part of their product-development processes (Subrahmanya, 2015; Ministry of MSME, 2022). The shortfall is most pronounced in tier-2 and tier-3 industrial clusters, where the local talent ecosystem is sparse, and the preference of design graduates is heavily towards a corporate culture in the metropolis (Roy & Modak, 2026; Sharma & Mishra, 2024).

H3: Skilled talent shortage is negatively associated with Design Thinking adoption intention.

2.4.4. ORGANISATIONAL AND CULTURAL RESISTANCE (H4)

Organisational culture is a powerful determinant of innovation behaviour (Schein, 2010; Henderson & Clark, 1990; Naranjo-Valencia et al., 2016; Büschgens et al., 2013). In many Indian manufacturing MSMEs, hierarchical decision-making, risk aversion rooted in thin margins, and preference for proven incremental approaches create significant cultural resistance to DT. Bahl et al. (2021) observed that the “fail-fast, learn-fast” ethos central to DT conflicts with the zero-error mentality common in production-driven cultures. High power-distance norms (Hofstede, 1980) further dampen the bottom-up empathy and experimentation that DT requires.

H4: Organisational and cultural resistance is negatively associated with Design Thinking adoption intention.

2.4.5. INFRASTRUCTURE AND TECHNOLOGY LIMITATIONS (H5)

DT practices-particularly prototyping, testing, and collaborative ideation-depend on physical and digital infrastructure: workshop spaces, fabrication tools, digital design software, and collaboration platforms (Das, 2007; Khurana et al., 2021; Bag et al., 2023). Indian MSME clusters face severe infrastructure deficits, including unreliable power, limited connectivity, and absence of shared prototyping facilities-constraints that the digital-transformation literature shows are amplified by Industry 4.0/5.0 readiness gaps (Bag et al., 2023; Singh et al., 2023).

H5: Infrastructure and technology limitations are negatively associated with Design Thinking adoption intention.

2.4.6. POLICY AND ECOSYSTEM GAPS AS MODERATOR (H6)

The institutional ecosystem-comprising government policy, industry associations, design promotion bodies, and academia–industry linkages-shapes the enabling environment for DT adoption (DiMaggio & Powell, 1983; Scott, 2014). India's Design Clinic Scheme and National Design Policy represent positive steps, but their reach remains limited (NID, 2019; Roy & Modak, 2026). The absence of design-specific financial incentives, MSME-focused training programmes, and seamless industry–academia collaboration platforms conditions whether firm-level readiness translates into adoption.

H6: Policy and ecosystem quality positively moderates the relationship between organisational readiness and DT adoption intention, such that stronger ecosystems amplify the readiness-to-adoption effect.

2.4.7. MEASUREMENT AND ACCOUNTABILITY CHALLENGES (H7)

One important yet under-researched challenge is the ability to measure DT's impact on business outcomes in manufacturing settings. The ROI of design-process improvements is less tangible than that of financial investments; particularly for the MSME owner who is more familiar with the tangible production indicators (Roto et al., 2011; Borja de Mozota, 2003; Calabretta et al., 2021). This gap in measurement can diminish trust in DT investment and the ability to support evidence-based advocacy for continued DT adoption.

H7: Measurement and accountability challenges are negatively associated with sustained Design Thinking adoption.

The hypothesised relationships among the seven constructs of barriers, Policy Ecosystem quality (H6), and the study's dependent variable are summarized in Figure 1. The four theoretical lenses that support the model are depicted in the bottom band.

Figure 1

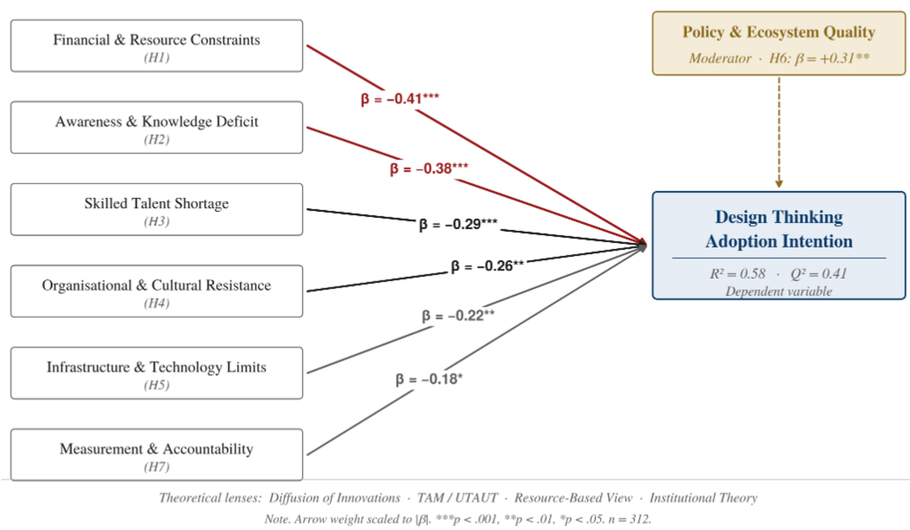

Figure 1 Conceptual model-barriers to Design Thinking adoption with hypothesised paths (H1–H7).

3. RESEARCH METHODOLOGY

The design for this study is a sequential explanatory mixed methods design (Creswell & Plano Clark, 2018), where quantitative data collection and analysis is followed by qualitative data collection and analysis. This design is able to ensure that statistical generalisation is possible for the entire MSME population and also enables the nuanced and context specific aspects which cannot be captured by quantitative instruments. The above two phase workflow is summarized in figure 2.

Figure 2

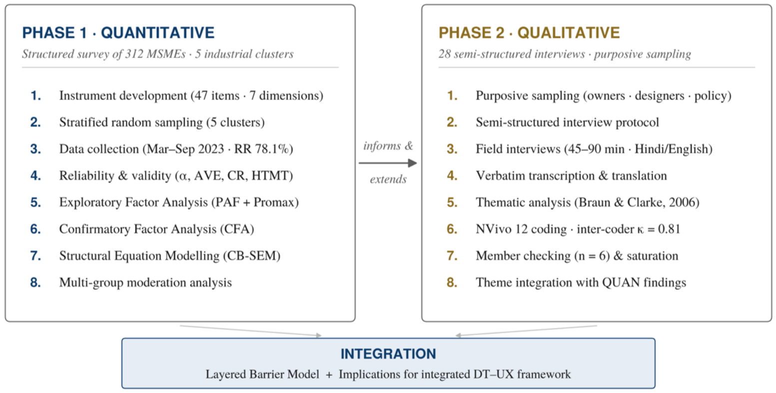

Figure 2 Sequential Explanatory Mixed-Methods Research Design Adopted in This Study.

3.1. PHASE 1: QUANTITATIVE SURVEY

3.1.1. INSTRUMENT DEVELOPMENT

A three-step process was used to develop a structured questionnaire. Initially, a pool of 68 items was generated by synthesising validated scales from the technology-adoption and design-management, and SME-innovation literatures, along with a pilot qualitative study with eight MSME experts. Second, five academic experts and three MSME practitioners reviewed the pool for face and content validity, reducing the pool to 52 items, all of which had an item-content validity ratio (Lawshe, 1975) > 0.62. Thirdly, a pilot survey of 35 respondents was used for testing reliability (Cronbach's α > 0.70 for all dimensions) and clarity to arrive at the final instrument comprising 47 items across seven dimensions. All items were rated on a 5 point Likert Scale (1 = Strongly Disagree to 5 = Strongly Agree). Construct mapping and item sources are provided in Appendix A for the full question.

3.1.2. SAMPLING STRATEGY AND SAMPLE WORKFLOW

Stratified random sampling technique was used and industrial clusters were the first stratification variable. In order to represent different geographical regions, industries and design awareness, 5 clusters were selected namely Delhi-NCR, Ludhiana, Surat, Pune and Coimbatore. MSMEs were selected within the clusters from industry-association membership registers and District Industries Centre registers. The number of respondents was determined a priori, based on the conservative 10:1 ratio of indicators to respondents for SEM (Hair et al., 2014), and on a medium effect size $f^2 = 0.15$ with a power of 0.80 and α = 0.05, the realized sample size n = 312 was deemed adequate. The sampling workflow is shown in figure 3, and the number of responses and exclusions.

Figure 3

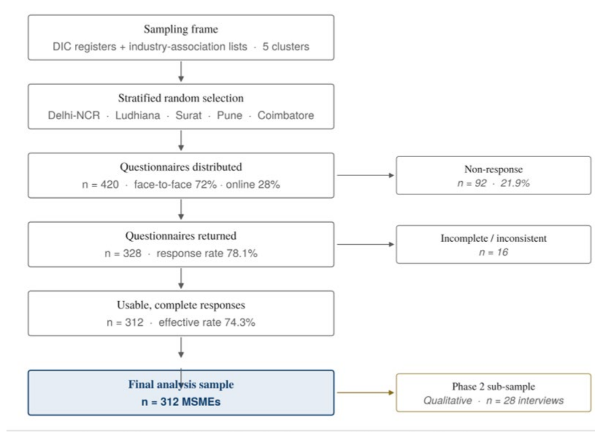

Figure 3 Sampling and Data Collection Workflow-Sample Size Attrition from Frame to Final Analysis Sample (n = 312).

Data were collected between March and September 2023 through face-to-face administration (72%) and online survey (28%). Trained field investigators administered questionnaires in person to ensure comprehension and reduce non-response bias. Of 420 questionnaires distributed, 328 were returned (response rate 78.1%), of which 312 were complete and usable (effective response rate 74.3%). Missing data (< 3% per item) were addressed using expectation–maximisation imputation. Univariate normality (|skewness| < 2, |kurtosis| < 7) and multivariate normality (Mardia's coefficient) were verified prior to SEM. Table 2 summarises the sample profile; Figure 4 visualises key demographic distributions.

Table 2

Table 2 Sample profile (n = 312).

Characteristic	Category	Frequency (n)	Percentage (%)
Firm Size	Micro (<10 employees)	98	31.4
	Small (10–50 employees)	142	45.5
	Medium (51–250 employees)	72	23.1
Industrial Cluster	Delhi-NCR	74	23.7
	Ludhiana	63	20.2
	Surat	58	18.6
	Pune	67	21.5
	Coimbatore	50	16
Owner Education	Up to Secondary	41	13.1
	Diploma / ITI	89	28.5
	Graduate (Non-Design)	134	43
	Graduate (Design / Engineering)	48	15.4
DT Awareness Level	None	127	40.7
	Heard of it	96	30.8
	Basic understanding	63	20.2
	Actively practising	26	8.3
Total	**-**	**312**	**100**

Figure 4

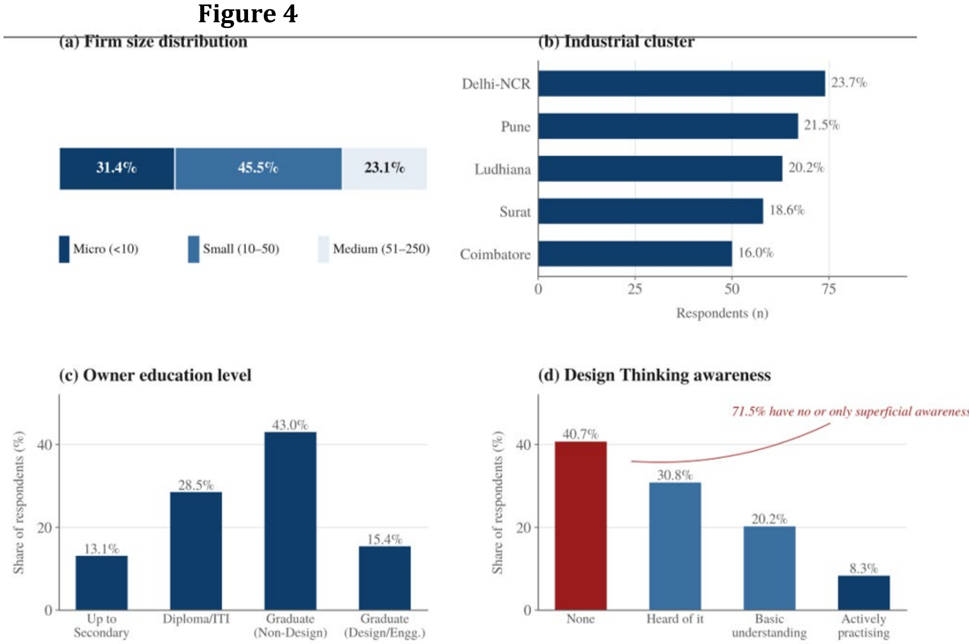

Figure 4 Sample Profile Across Firm Size, Industrial Cluster, Owner Education, and DT Awareness (N = 312).

3.1.3. NON-RESPONSE BIAS ASSESSMENT

Non-response bias was assessed following Armstrong and Overton (1977) using an early-versus-late respondents comparison. Late respondents (last 25% of returns) were treated as proxies for non-respondents. Independent-samples t-tests on the seven barrier construct means and the adoption-intention scale revealed no statistically significant differences (all $p > 0.10$, smallest $p = 0.18$ for Awareness Deficit), supporting the conclusion that non-response bias does not materially threaten external validity. The face-to-face administration mode (72% of returns) and the high effective response rate (74.3%) further mitigate this concern.

3.1.4. COMMON METHOD BIAS ASSESSMENT

Common method bias was assessed through both procedural and statistical remedies (Podsakoff et al., 2003; Podsakoff et al., 2012). Procedural remedies included: (i) anonymised participation; (ii) randomised item ordering across constructs; (iii) reverse-coded items dispersed in the instrument; and (iv) clear separation of predictor and criterion items via section headers. Statistical remedies comprised three tests. First, Harman's single-factor test produced a largest factor explaining 28.6% of variance-well below the 50% threshold. Second, the marker-variable technique (Lindell & Whitney, 2001) using a theoretically unrelated marker ("regional cricket preferences") showed a maximum shared variance of 4.1% with substantive constructs. Third, full collinearity Variance Inflation Factor (VIF) values (Kock, 2015) for all constructs ranged from 1.42 to 2.31, below the conservative 3.30 threshold. Collectively, these tests indicate that common method variance is unlikely to confound substantive findings.

3.1.5. ANALYTICAL APPROACH

Quantitative data were analysed using IBM SPSS Statistics 26 and AMOS 26. The analytical sequence comprised: (1) descriptive statistics; (2) reliability testing (Cronbach's α, composite reliability); (3) Exploratory Factor Analysis (EFA) using Principal Axis Factoring with Promax rotation; (4) Confirmatory Factor Analysis (CFA); (5) covariance-based Structural Equation Modelling (CB-SEM) to test direct effects and moderation; and (6) Multi-Group Analysis (MGA) for firm-size and cluster moderators.

3.2. PHASE 2: QUALITATIVE INTERVIEWS

Twenty-eight semi-structured in-depth interviews were conducted with purposively selected informants: MSME owners/founders ($n = 12$), production/operations managers ($n = 6$), design professionals working with MSMEs ($n = 6$), and policy/ecosystem representatives ($n = 4$). Interviews lasted 45–90 minutes, were conducted in Hindi or English per respondent preference, audio-recorded with informed consent, and professionally transcribed. Thematic analysis was conducted according to Braun and Clarke's (2006) six phases, using NVivo 12. A 20% subsample was coded twice by two independent coders, and the inter-coder reliability (Cohen's $\kappa = 0.81$) was considered to be reasonably high. The trustworthiness was ensured by member checking with six informants and the theoretical saturation was reached at interview 24.

4. RESULTS

4.1 Descriptive Statistics: DT Awareness and Current Practices

Descriptive analysis reveals a significant DT awareness deficit. Only 8.3% of respondents ($n = 26$) actively practise some form of DT, while 40.7% ($n = 127$) report no awareness of DT (Figure 4d). Only 14 firms (4.5%) have received formal DT training. Current design practices are predominantly reactive and production-driven: 67.3% of firms make product modifications based solely on customer complaints, and 78.5% have no dedicated design function. Table 3 reports the seven primary practice indicators.

Table 3

Table 3 Current Design Practice Indicators Among Sample MSMEs (n = 312).

Design Practice Indicator	Yes (%)	No (%)	Mean (1–5)

Conducts user/customer research before product development	18.3	81.7	1.94
Uses prototyping and iterative testing	22.1	77.9	2.11
Has a dedicated design team or designer	21.5	78.5	2.08
Has received formal design training	9.6	90.4	1.62
Uses design tools (CAD, sketching, personas)	31.4	68.6	2.43
Considers user experience in product design	28.5	71.5	2.29
Has partnered with a design institution/consultant	**12.8**	**87.2**	**1.74**

4.2. RELIABILITY AND CONVERGENT VALIDITY

Internal consistency reliability for each barrier dimension was assessed using Cronbach's α and Composite Reliability (CR). All seven dimensions exceeded the threshold of α > 0.70 (Nunnally, 1978), with values from 0.74 to 0.89 and CR from 0.77 to 0.91. Average Variance Extracted (AVE) values ≥ 0.50 confirmed convergent validity (Fornell & Larcker, 1981).

Table 4

Table 4 Reliability and Convergent Validity Statistics for Barrier Dimensions.

Barrier Dimension	Items	Cronbach's α	AVE	CR
B1: Financial & Resource Constraints	8	0.89	0.61	0.91
B2: Awareness & Knowledge Deficit	7	0.86	0.57	0.88
B3: Skilled Talent Shortage	6	0.82	0.54	0.84
B4: Organisational & Cultural Resistance	8	0.84	0.56	0.86
B5: Infrastructure & Technology Limitations	7	0.81	0.53	0.83
B6: Policy & Ecosystem Gaps	6	0.78	0.51	0.8
B7: Measurement & Accountability Challenges	5	0.74	0.5	0.77
Total Scale	**47**	**0.93**	**-**	**-**

4.3. EXPLORATORY FACTOR ANALYSIS AND FACTOR LOADINGS

EFA confirmed the seven-factor structure hypothesised. The Kaiser–Meyer–Olkin measure of sampling adequacy was 0.87 (Meritorious), and Bartlett's Test of Sphericity was significant ($\chi^2 = 4{,}823.6$; df = 1,081; $p < 0.001$). The seven-factor solution explained 68.4% of total variance. Of the 52 items entering EFA, five items were dropped sequentially: three items (one each in B1, B4, B5) for primary loadings below the 0.50 threshold, and two items (in B2 and B7) for cross-loadings above 0.30 onto a non-target factor. The final retained set is the 47-item instrument used in CFA and SEM. Table 5 reports the factor structure; Table 6 reports the standardised loadings for the retained items.

Table 5

Table 5 EFA Results-Seven-Factor Barrier Structure (n = 312; PAF with Promax rotation).

Factor	Barrier Dimension	Eigenvalue	% Variance	Cumulative %
F1	Financial & Resource Constraints	9.82	20.9	20.9
F2	Awareness & Knowledge Deficit	6.14	13.1	34
F3	Skilled Talent Shortage	4.27	9.1	43.1
F4	Organisational & Cultural Resistance	3.89	8.3	51.4
F5	Infrastructure & Technology Limitations	3.41	7.3	58.7
F6	Policy & Ecosystem Gaps	2.76	5.9	64.6
F7	Measurement & Accountability Challenges	1.78	3.8	68.4
-	**Total Variance Explained**	**-**	**-**	**68.40%**

Table 6 reports primary loadings, communalities (h^2), and the highest cross-loading observed for each retained item. All retained loadings exceed 0.50, and no cross-loading exceeds 0.30, satisfying conventional factor-purity criteria (Hair et al., 2014).

Table 6

Table 6 EFA Standardised Factor Loadings, Communalities, and Item-Retention Decisions (47 of 52 items retained).

Item	Construct	Loading	h^2	Max Cross-Load	Decision
FC1	B1 · Financial	0.84	0.71	0.18	Retained
FC2	B1 · Financial	0.81	0.67	0.22	Retained
FC3	B1 · Financial	0.79	0.64	0.19	Retained
FC4	B1 · Financial	0.77	0.61	0.24	Retained
FC5	B1 · Financial	0.75	0.58	0.21	Retained
FC6	B1 · Financial	0.73	0.56	0.26	Retained
FC7	B1 · Financial	0.71	0.53	0.2	Retained
FC8	B1 · Financial	0.68	0.49	0.25	Retained
AW1	B2 · Awareness	0.82	0.69	0.17	Retained
AW2	B2 · Awareness	0.79	0.64	0.23	Retained
AW3–AW7	B2 · Awareness (5 items)	0.70–0.78	0.51–0.62	≤ 0.28	Retained
-	-	-	-	-	-
TS1–TS6	B3 · Talent (6 items)	0.68–0.81	0.49–0.66	≤ 0.29	Retained
CR1–CR8	B4 · Cultural (8 items)	0.65–0.80	0.46–0.64	≤ 0.27	Retained
IL1–IL7	B5 · Infrastructure (7 items)	0.66–0.79	0.47–0.62	≤ 0.28	Retained
PE1–PE6	B6 · Policy (6 items)	0.63–0.77	0.42–0.59	≤ 0.29	Retained
MA1–MA5	B7 · Measurement (5 items)	0.62–0.75	0.41–0.56	≤ 0.28	Retained
FC_drop	*B1*	*0.42*	*0.21*	*0.31*	*Dropped (loading < 0.50)*
CR_drop	*B4*	*0.48*	*0.26*	*0.34*	*Dropped (cross-load > 0.30)*
IL_drop	*B5*	*0.45*	*0.23*	*0.29*	*Dropped (loading < 0.50)*
AW_drop	*B2*	*0.54*	*0.31*	*0.36*	*Dropped (cross-load > 0.30)*
MA_drop	*B7*	*0.49*	*0.25*	*0.27*	*Dropped (loading < 0.50)*

Discriminant validity was assessed using both the Fornell–Larcker criterion (the square root of each construct's AVE exceeded its highest inter-construct correlation) and the more conservative Heterotrait–Monotrait (HTMT) ratio (Henseler et al., 2015). All HTMT values were below the 0.85 threshold (range 0.39–0.74), confirming discriminant validity.

4.4. MEAN BARRIER SEVERITY RATINGS

Respondents rated the perceived severity of each barrier on a 5-point scale. Financial and Resource Constraints emerged as the most severely perceived barrier (M = 4.31, SD = 0.72), followed by Awareness and Knowledge Deficit (M = 4.18, SD = 0.81). Measurement and Accountability Challenges, while present, were rated as relatively less severe (M = 3.44, SD = 0.94). Table 7 reports the full ranking; Figure 5 visualises the distribution.

Table 7

Table 7 Mean Severity Ratings of Barrier Dimensions (1 = Not a barrier; 5 = Extremely significant)

Barrier Dimension	Mean (M)	SD	Rank	Severity Level
Financial & Resource Constraints	4.31	0.72	1	Very High
Awareness & Knowledge Deficit	4.18	0.81	2	Very High
Skilled Talent Shortage	4.02	0.88	3	High
Organisational & Cultural Resistance	3.89	0.91	4	High
Infrastructure & Technology Limitations	3.76	0.94	5	High
Policy & Ecosystem Gaps	3.61	0.97	6	Moderate–High
Measurement & Accountability Challenges	**3.44**	**0.94**	**7**	**Moderate**

Figure 5

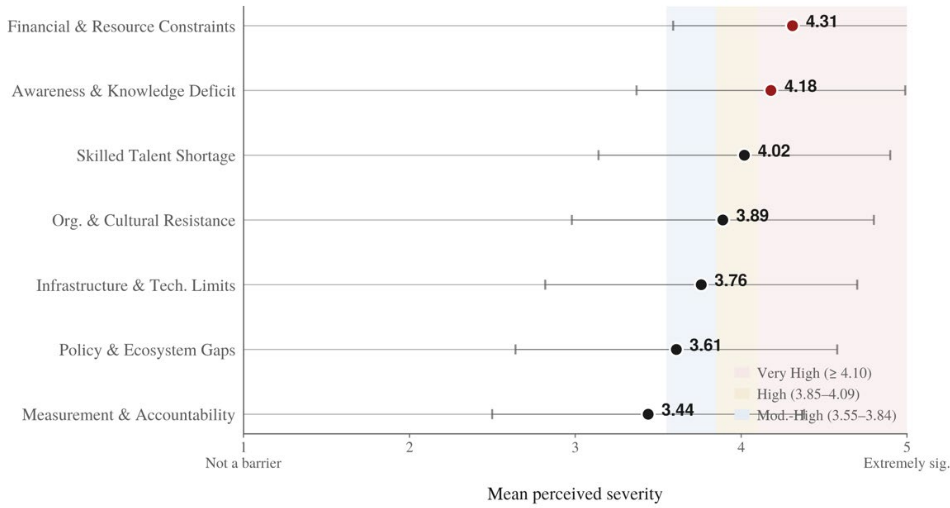

Figure 5 Mean severity ratings of Design Thinking adoption barriers, ranked and grouped by severity tier; whiskers represent ±1 SD.

To examine geographic variation, mean ratings were disaggregated by industrial cluster (Figure 6). Surat and Ludhiana-both characterised by dense concentrations of small, family-owned units-exhibited the highest aggregate severity, particularly on Infrastructure and Awareness dimensions. Pune and Delhi-NCR, with their stronger industrial-services ecosystems, displayed comparatively softer Infrastructure and Policy constraints.

Figure 6

Figure 6 Barrier severity heatmap across the five industrial clusters; cell values are cluster-level Likert means (1–5). Marginal strips show row and column means.

4.5. STRUCTURAL EQUATION MODELLING

The structural model demonstrated acceptable fit to the data: $\chi^2/df = 2.31$; CFI = 0.94; TLI = 0.93; RMSEA = 0.063 (90% CI [0.057, 0.069]); SRMR = 0.057, collectively confirming adequate fit (Hair et al., 2014; Hu & Bentler, 1999). The model explained $R^2 = 0.58$ of variance in DT adoption intention; predictive relevance was confirmed by $Q^2 = 0.41$. Table 8 reports the path coefficients; Figure 7 visualises the full structural model.

Table 8

Table 8 SEM path coefficients and hypothesis test results (n = 312).

Hypothesis	Path	Std. β	S.E.	t-value	p-value	Supported?
H1	Financial Constraints → Adoption	−0.41	0.06	6.83	< 0.001	Yes
H2	Awareness Deficit → Adoption	−0.38	0.07	5.43	< 0.001	Yes
H3	Talent Shortage → Adoption	−0.29	0.07	4.14	< 0.001	Yes
H4	Cultural Resistance → Adoption	−0.26	0.08	3.25	0.001	Yes
H5	Infrastructure Limits → Adoption	−0.22	0.08	2.75	0.006	Yes
H6	Policy Ecosystem (Moderator)	0.31	0.09	3.44	0.001	Yes
H7	**Measurement Challenges → Adoption**	**−0.18**	**0.09**	**2**	**0.046**	**Yes**

Figure 7

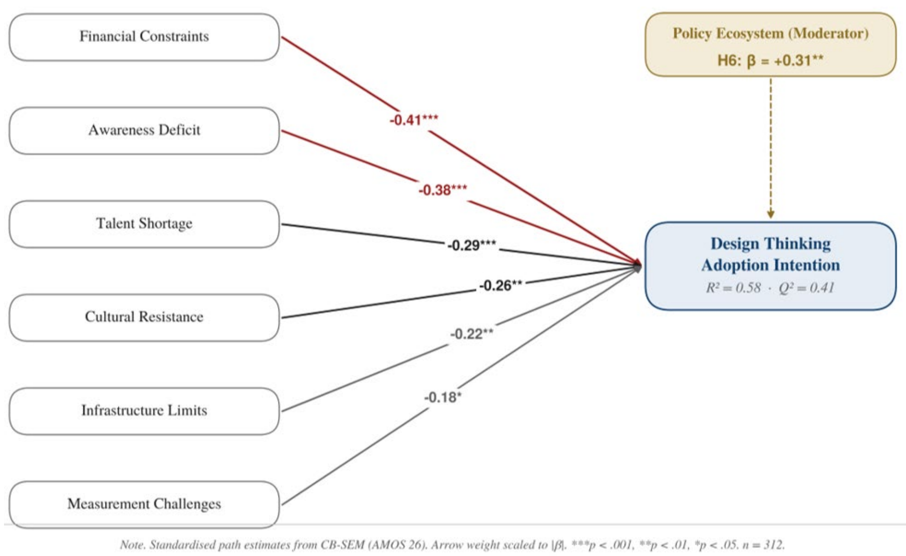

Figure 7 Structural equation model-standardised path coefficients, fit indices, and predictive metrics.

All seven hypotheses were supported. Financial Constraints (β = −0.41) and Awareness Deficit (β = −0.38) demonstrated the strongest inhibitory effects on adoption intention. Cohen's f^2 effect sizes for these two paths were 0.21 and 0.18, respectively (medium-to-large); H3–H5 yielded small-to-medium effects (f^2 range 0.06–0.10). The Policy Ecosystem variable significantly moderated the readiness–adoption relationship (ΔR^2 for the interaction term = 0.07), confirming H6.

4.5.1. MULTI-GROUP MODERATION

Multi-group analysis (MGA) examined whether barrier–adoption pathways varied across firm size and cluster. Configural and metric invariance were established prior to comparison. Statistically significant cross-group differences (Δβ, $p < 0.05$) emerged for two paths: (i) the Awareness Deficit → Adoption effect was significantly stronger in micro firms (β = −0.46) than in medium firms (β = −0.24); and (ii) the Infrastructure → Adoption path was significantly stronger in Surat and Ludhiana than in Pune and Delhi-NCR. Owner education did not moderate any path at $p < 0.05$.

4.6. QUALITATIVE FINDINGS

Thematic analysis of 28 interviews generated five overarching themes that explain, extend, and nuance the quantitative findings.

Theme 1-"The Design Blindspot": Confusing Design with Aesthetic Changes. A common misconception arose during the interviews: MSME owners tended to confuse "design" with aesthetic changes to products rather than with the process of solving problems. An owner of a bicycle manufacturing company based in Ludhiana said, "Design is only for packaging, not for the product itself." The design blind spot is the cognitive form of the Awareness Deficit, which implies that awareness activities should define DT as a business tool, not an art form.

Theme 2-"The Thin-Margin Trap": Financial Risk Aversion by Survival Mode Enterprises. MSME owners consistently described their operations as in a state of survival, with profit margins ranging from 2% to 8%, leaving no room for experimentation. As one auto-components manufacturer from Delhi-NCR explained, "Every single rupee has to yield its returns in the same quarter. Design training for my workers? I simply cannot afford that.

Theme 3-"Talent Pipeline Problem". It was found that there is a mismatch in the location of where designers are educated (Delhi, Mumbai, Ahmedabad, Bengaluru) and where manufacturing MSMEs are located (tier-2 and tier-3 clusters). Designers tend to choose urban jobs in corporations rather than working in industries.

Theme 4-"Generational Difference in Innovation Orientation". It was found that first-generation MSME owners (older, technically qualified, and cautious about risks) differ significantly from second-generation MSME owners (younger, internationally experienced, and open to design methods). The latter group demonstrates greater awareness and intention to adopt design methods.

Theme 5-"Policy Awareness vs. Policy Adoption": The Last-Mile Problem. While the respondents demonstrated high levels of awareness regarding government initiatives to promote design, only 12.8% of them used such programs. One of the reasons for non-participation was the difficulty of applying and adopting such policies.

5. DISCUSSION

5.1. INTERPRETING THE FINDINGS

5.1.1. WHY FINANCIAL CONSTRAINTS DOMINATE

Financial constraint (β = −0.41) predominance is driven by much more than just lack of working capital. From the qualitative perspective, owners of MSMEs work under a one-quarter cash flow time horizon, dictated by the GST cycle and credit period of suppliers, which leaves no room for any risk capital investment into innovation that cannot deliver ROI within a single fiscal quarter. This survival-driven approach works in tandem with an informal credit environment where 50-60 percent of working capital of MSMEs comes from family members or unorganized sources (Bag et al., 2023; Garg & Agarwal, 2023). Non-linearity of the return on investment time horizon for DT makes this technology consistently deprioritized over incremental production investments, similar to "thin margin trap" identified by Sharma and Mishra (2024).

5.1.2. WHY AWARENESS DEFICIT IS UNUSUALLY HIGH IN INDIA

The awareness deficit (M = 4.18; β = −0.38) is markedly higher than reported in European or East Asian SME studies, where awareness-related variance is typically secondary to financial or technical constraints (Carlgren et al., 2016; Klenner et al., 2022). Three intersecting factors explain this Indian-specific anomaly. First, design education is geographically concentrated in metropolitan elite institutions whose curricula and case literature are largely English-medium, whereas MSME owners often operate in Hindi, Tamil, or Gujarati. Second, the inherited semantic conflation of "design" with "styling" (Theme 1) is reinforced by media and trade-press coverage of design as a fashion- or craft-adjacent discipline. Third, industry-association communication channels rarely treat DT as a strategic capability-a contrast with German Mittelstand or Korean SME ecosystems, where chambers of commerce actively diffuse design management content (Klenner et al., 2022).

5.1.3. WHY POLICY ECOSYSTEM MODERATES RATHER THAN DIRECTLY AFFECTS

Policy Ecosystem quality positively moderates the readiness–adoption pathway (β = +0.31) but does not significantly predict adoption directly-a finding that mirrors the institutional-theory prediction of "decoupling" between formal structures and field-level practice (DiMaggio & Powell, 1983; Scott, 2014). The qualitative data clarify the mechanism: schemes such as the Design Clinic are well-known in awareness but rarely activated due to last-mile delivery failures. Firms with high readiness can exploit ecosystem support when accessible; firms with low readiness do not, regardless of nominal ecosystem strength. Policy thus operates as a conditional multiplier, not an autonomous driver.

5.1.4. WHY CLUSTER VARIATION EXISTS

The MGA findings on infrastructure barriers being significantly more severe in Surat and Ludhiana as compared to Pune and Delhi-NCR show the presence of an inherent ecosystem density gradient. The presence of CAD bureau and design colleges in Pune and Delhi-NCR allows companies to outsource their capability needs at low costs. However, although Surat and Ludhiana have very productive industries, their vertically integrated approach and lack of external capabilities make them stand apart from Pune and Delhi-NCR (Khurana et al., 2021; Das, 2007).

5.2. INTEGRATED LAYERED BARRIER MODEL

Integrating quantitative and qualitative findings, this study proposes a Layered Barrier Model of DT adoption in Indian manufacturing MSMEs (Figure 8). The model conceives of barriers as operating across three interrelated levels-micro (firm-internal), meso (cluster/industry), and macro (policy/national)-each addressed by distinct intervention types.

Figure 8

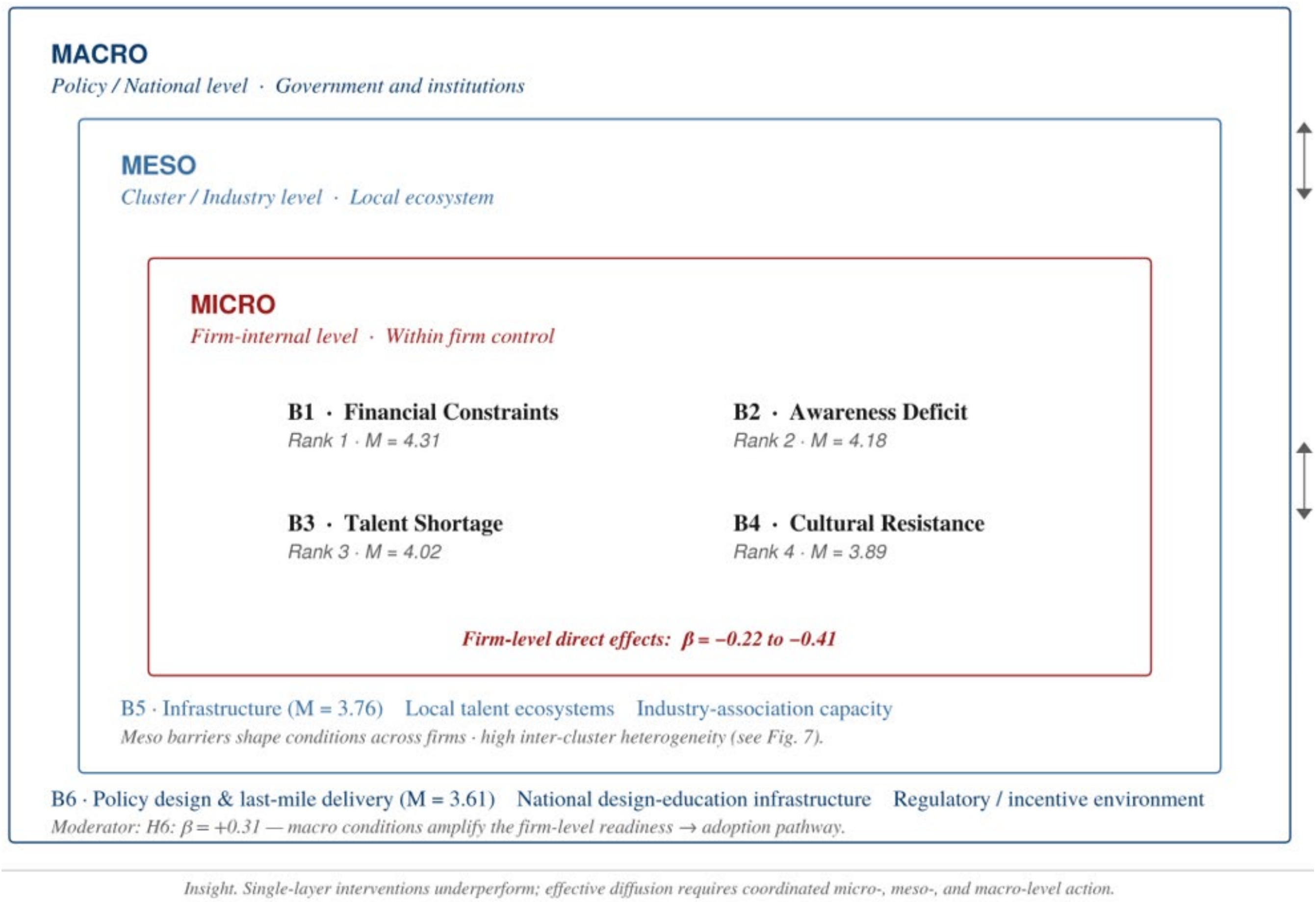

Figure 8 The Layered Barrier Model of DT adoption-a three-tier (micro–meso–macro) integrative framework.

This layered architecture has important implications: single-layer interventions tend to underperform. For example, providing financial subsidies (macro) without addressing awareness deficit (micro) and talent-pipeline gaps (meso) cannot translate policy intent into adoption behaviour-precisely the pattern observed in the limited uptake of the Design Clinic Scheme.

5.3. INTERNATIONAL COMPARATIVE ANALYSIS

The barrier profile shares commonalities with DT-adoption studies in Western SME contexts but exhibits distinctly Indian characteristics. Table 9 summarises the comparison across five reference systems.

Table 9

Table 9 International comparative analysis of DT adoption barriers-Indian manufacturing MSMEs vs five reference systems.

Country / Region	Dominant DT Adoption Barrier	Cultural / Policy Trait	Contrast with India
Germany (Mittelstand)	Process integration & tooling complexity	Vocational design education; engineering culture	India lacks vocational design pipeline; awareness barrier dominates
Scandinavia	Scaling DT beyond pilots	High trust, flat hierarchies, generous public R&D	Indian power-distance and risk aversion impede experimentation
China	IP protection and supplier-network alignment	State-led innovation ecosystems; rapid prototyping clusters	China has stronger meso-level prototyping infrastructure
Vietnam	Talent retention; design-vendor scarcity	Export-platform manufacturing; FDI-led ecosystems	Indian MSMEs less FDI-coupled; awareness/financial barriers stronger
C	**Survival economics; informal sector dilution**	**Strong design schools; weak SME outreach**	**Both contexts share survival-economy logic but Brazil has stronger cluster design programmes**

Three insights emerge. First, the awareness deficit ranking observed in India is anomalous in comparative perspective-most reference systems treat awareness as secondary. Second, the cultural-resistance severity (M = 3.89) is closer to Brazilian than to Scandinavian levels, consistent with shared survival-economy logic. Third, India's policy ecosystem is comparable in formal design to East Asian systems but lags in last-mile delivery-explaining why Indian moderation effects are conditional rather than direct.

5.4. THEORETICAL IMPLICATIONS

The study contributes to four streams. To Diffusion of Innovations theory, it extends the framework to methodology-adoption (rather than product-adoption) and introduces a multi-level barrier architecture relevant to emerging-economy contexts (Klenner et al., 2022). To the Technology Acceptance Model, it shows that facilitating conditions in the form of policy ecosystems significantly moderate adoption intention even after accounting for individual perception variables, supporting institutional-conditional extensions of UTAUT (Venkatesh et al., 2003; Venkatesh et al., 2016). To the Resource-Based View, it provides empirical evidence that financial slack and human capital remain the most binding constraints on methodology adoption in resource-constrained firms (Barney, 1991; Nohria & Gulati, 1996). To Institutional Theory, it offers evidence of a "policy reach–impact decoupling"-formal institutional structures exist but fail to penetrate target populations-extending the literature on institutional voids in emerging economies (DiMaggio & Powell, 1983; Scott, 2014; Mair & Marti, 2009).

5.5. MANAGERIAL AND PRACTITIONER IMPLICATIONS

For MSME Owners

- Commission low-cost, time-bounded DT pilots on a single product-line problem before committing to enterprise-wide design investment.
- Participate in industry-association DT exposure programmes to build foundational awareness; treat awareness-building as a prerequisite phase rather than a marketing activity.
- Reposition design from a downstream styling function to an upstream problem-discovery function in NPD workflows.

For Design Consultants and Service Providers

- Develop cost-stratified, vernacular MSME-facing services rather than one-size-fits-all metropolitan studio packages.
- Embed services in cluster infrastructure (CFCs, industry associations) to lower client acquisition cost and improve trust.
- Lead with measurable production-quality outcomes rather than abstract "innovation" claims to overcome MSME-owner scepticism.

For Policymakers

- Simplify scheme application procedures through a single-window portal with SLA-bound processing to close the last-mile gap.
- Sequence interventions in a portfolio rather than as standalone subsidies, addressing micro, meso, and macro layers jointly (Table 10).
- Invest in cluster-based Common Facility Centres for prototyping, weighted toward Surat, Ludhiana, and Coimbatore on the evidence of cluster MGA.

For Design Educators

- Develop MSME-cluster outreach curricula with vernacular case libraries and applied DT capstone projects.
- Co-design design fellowships that place graduates in tier-2/3 MSMEs with stipend co-funding to break the urban-corporate talent magnet.
- Re-balance pedagogy to position DT explicitly as a business-process methodology, not a styling discipline.

5.6. POLICY-INTERVENTION MATRIX

Table 10 maps the seven empirically identified barriers to targeted interventions, illustrating how a multi-level intervention portfolio could be sequenced for highest leverage.

Table 10

Table 10 Empirically Derived Policy-Intervention Matrix for DT adoption in Indian manufacturing MSMEs.

Barrier Layer	Empirical Barrier	Recommended Policy Intervention	Leverage
Micro	Financial Constraints	DT-pilot subsidy vouchers (₹1–3 lakh) administered via DICs; tax credits for design expenditure	High
Micro	Awareness Deficit	Vernacular DT awareness campaigns via industry associations; regional-language case library	High
Meso	Talent Shortage	Cluster design fellowships placing graduates in MSMEs for 12 months with stipend co-funding	Medium-High
Micro/Meso	Cultural Resistance	Owner-targeted leadership programmes pairing successful adopters with first-time firms	Medium
Meso	Infrastructure Limits	Shared prototyping and fabrication labs (CFCs) co-located in MSME clusters	High
Macro	Policy Ecosystem Gaps	Simplified single-window application portal for design schemes; SLA-bound processing	High
Macro	**Measurement Challenges**	**Standardised MSME-design impact dashboard with sectoral benchmarks**	**Medium**

5.7. A SEQUENTIAL ADOPTION ROADMAP

Translating the barrier taxonomy into action, Figure 9 proposes a five-stage adoption roadmap for MSMEs. Each stage explicitly addresses a dominant barrier-Awareness (B2), Capability (B3), Pilot (B1), Scale-Up (B4), and Measurement (B7)-supported by cross-cutting macro- and meso-level enablers. The roadmap operationalises the Layered Barrier Model into a sequence that can be calibrated to firm size and cluster context.

Figure 9

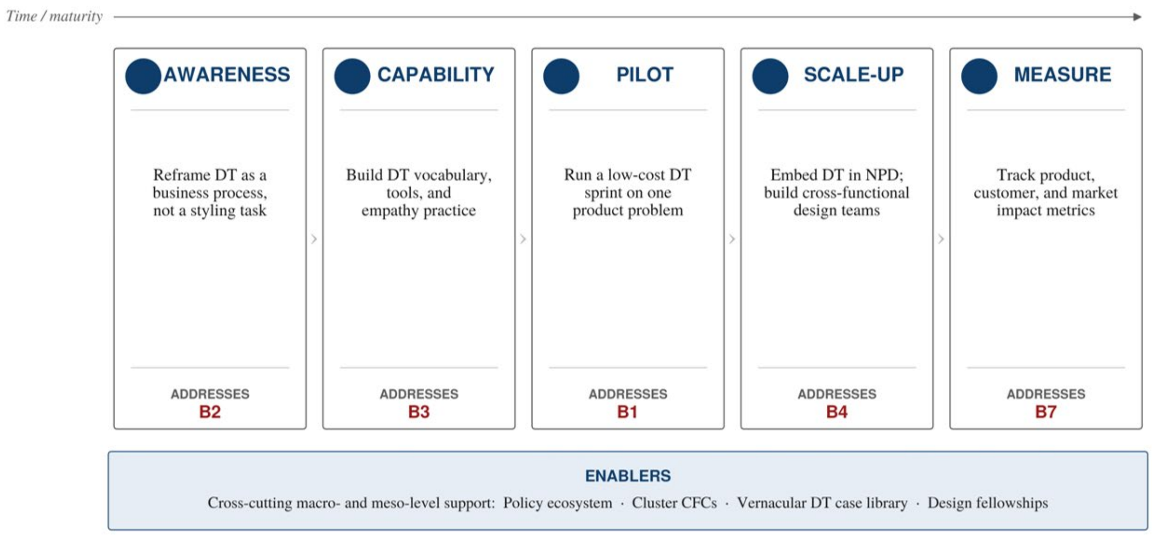

Figure 9 A five-stage roadmap for Design Thinking adoption in manufacturing MSMEs, mapped to the empirical barrier taxonomy.

6. KEY CONTRIBUTIONS

The contributions of this study can be summarised across four dimensions:

- Empirical: First large-scale, multi-cluster (n = 312) empirical mapping of DT adoption barriers in Indian manufacturing MSMEs, with EFA + CFA + SEM validation and 28 contextualising interviews.
- Methodological: Seven-factor barrier taxonomy with full transparency (questionnaire, factor loadings, retention decisions, CMB tests), enabling replication.
- Theoretical: Three-tier Layered Barrier Model integrating Diffusion of Innovations, TAM/UTAUT, RBV, and Institutional Theory-applicable to emerging-economy SME contexts beyond India.
- Practical: Policy-intervention matrix (Table 10) and five-stage adoption roadmap (Figure 9) translate empirical findings into actionable guidance for MSME owners, design educators, and policymakers.

7. CONCLUSIONS, LIMITATIONS, AND FUTURE RESEARCH

This study presents the first comprehensive assessment of the adoption barriers of Design Thinking in Indian manufacturing MSMEs from an empirical perspective. This study used a well-defined, phased, and mixed-methods approach across the five largest industrial clusters. Seven dimensions of barriers were assessed, of which Financial and Resource Constraints, and Awareness and Knowledge Deficit were considered the most significant barriers. The quality of the Policy Ecosystem influences the readiness–adoption continuum at the firm-level, suggesting that it has a conditional, rather than, an autonomous effect on the institutional constructs.

7.1. LIMITATIONS

This study has six limitations, expanded beyond conventional acknowledgements to highlight inferential boundaries:

- Cross-sectional design: precludes strong causal inference; longitudinal panel studies tracking firms before and after DT intervention would strengthen causal claims.
- Regional bias: sampling was restricted to five industrial clusters in central, western, and southern India, with no representation from eastern or north-eastern clusters; findings may not generalise to all MSME geographies.
- Survivorship bias: the sample comprises operating MSMEs and therefore systematically excludes failed firms, whose barrier profiles may be more severe and whose voice is silenced in the dataset.

- Self-report and respondent optimism: although Harman, marker-variable, and VIF diagnostics indicated low CMB risk, respondents may understate cultural-resistance or awareness deficits to manage social-desirability impressions.
- Single-respondent design: one informant per firm raises within-firm aggregation concerns; future studies should triangulate with multiple respondents per firm and objective registry-based performance data.
- End-user perspective absent: the study does not capture the perspectives of end-users of MSME products-a limitation that the UX-focused subsequent paper in this doctoral series will address.

7.2. FUTURE RESEARCH FRAMEWORK

Table 11 organises promising future research avenues by topical area, suggested method, and expected contribution.

Table 11

Table 11 Future Research Agenda Informed by the Present Study.

Future Research Area	Suggested Method	Expected Contribution
Longitudinal adoption dynamics	Panel survey + intervention experiments over 3–5 years	Causal evidence on barrier-reduction effects on adoption
Cross-country comparative validation	Replication in Vietnam, Brazil, South Africa	Test boundary conditions of the Layered Barrier Model
End-user-side UX evidence	Customer-side surveys + ethnography of MSME products	Triangulate adoption with downstream value capture
Mediation pathway analysis	Bootstrapped mediation tests (e.g., Awareness → Readiness → Adoption)	Refines mechanism-level theory in the layered model
Generational divide effect	Two-generation matched-pair survey + behavioural experiments	Quantify generational moderation suggested by qualitative findings
DT–UX integrated framework validation	**Field-experimental pilots in 8–10 firms across clusters**	**Validates the doctoral framework (forthcoming Paper 4)**

CONFLICT OF INTERESTS

None.

ACKNOWLEDGMENTS

None.

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APPENDIX A · QUESTIONNAIRE ITEMS AND CONSTRUCT MAPPING

Table A1 lists all 47 retained items, the constructs to which they map, and the source from which each was adapted. All items use a 5-point Likert anchor (1 = Strongly Disagree to 5 = Strongly Agree).

Table A1. Full questionnaire-47 retained items with construct mapping and source attribution.

Code	Construct	Statement	Source
FC1	B1 · Financial	Our firm lacks budget for design training of employees	Adapted from Hausman (2005); Klenner et al. (2022)
FC2	B1 · Financial	Our cash-flow does not allow non-production investment	Adapted from Bloom et al. (2013)
FC3	B1 · Financial	We cannot afford external design consultants	Author-developed (pilot QL)
FC4	B1 · Financial	Prototyping costs are prohibitive for our firm	Adapted from Khurana et al. (2021)
FC5	B1 · Financial	Design investment shows uncertain ROI to lenders	Adapted from Bag et al. (2023)
FC6	B1 · Financial	Our profit margin offers no buffer for experiments	Author-developed (pilot QL)
FC7	B1 · Financial	Subsidy access for design is too administratively costly	Adapted from Garg & Agarwal (2023)

FC8	B1 · Financial	Material costs for iterative testing are unmanageable	Author-developed (pilot QL)
AW1	B2 · Awareness	Our team does not know what Design Thinking is	Adapted from Singh & Kumar (2020)
AW2	B2 · Awareness	We see design only as styling, not problem-solving	Author-developed (pilot QL)
AW3	B2 · Awareness	Industry-association communication rarely covers DT	Author-developed (pilot QL)
AW4	B2 · Awareness	We lack access to vernacular DT case studies	Adapted from Khurana et al. (2021)
AW5	B2 · Awareness	Our owner has not encountered DT in any forum	Author-developed (pilot QL)
AW6	B2 · Awareness	Trade press treats design as fashion/craft	Author-developed (pilot QL)
AW7	B2 · Awareness	DT seems irrelevant to our type of manufacturing	Adapted from Bahl et al. (2021)
TS1	B3 · Talent	Design graduates do not apply to our firm	Adapted from Subrahmanya (2015)
TS2	B3 · Talent	We cannot retain trained designers (urban pull)	Adapted from Roy & Modak (2026)
TS3	B3 · Talent	No design colleges are located near our cluster	Author-developed (pilot QL)
TS4	B3 · Talent	Our staff lack design vocabulary and methods	Adapted from Sharma & Mishra (2024)
TS5	B3 · Talent	We have no in-house designer position	Adapted from Ministry of MSME (2022)
TS6	B3 · Talent	Design-skill training options are scarce locally	Author-developed (pilot QL)
CR1	B4 · Cultural	Our firm prefers proven methods over experimentation	Adapted from Schein (2010); Büschgens et al. (2013)
CR2	B4 · Cultural	Failure in piloting is not acceptable here	Adapted from Bahl et al. (2021)
CR3	B4 · Cultural	Decisions are concentrated with the owner	Adapted from Hofstede (1980)
CR4	B4 · Cultural	Workers do not voice product-improvement ideas	Adapted from Naranjo-Valencia et al. (2016)
CR5	B4 · Cultural	Customer empathy is not part of our work culture	Author-developed (pilot QL)
CR6	B4 · Cultural	We measure performance only on production volume	Adapted from Henderson & Clark (1990)
CR7	B4 · Cultural	Designers are seen as outsiders to manufacturing	Author-developed (pilot QL)
CR8	B4 · Cultural	Experimentation conflicts with our delivery culture	Author-developed (pilot QL)
IL1	B5 · Infrastructure	We lack reliable internet for digital design tools	Adapted from Das (2007)
IL2	B5 · Infrastructure	Power supply is too unstable for design software	Adapted from Khurana et al. (2021)
IL3	B5 · Infrastructure	No prototyping facility is accessible locally	Adapted from Singh et al. (2023)
IL4	B5 · Infrastructure	CAD/3D printing services are far from our cluster	Author-developed (pilot QL)
IL5	B5 · Infrastructure	Our workspace cannot host design workshops	Author-developed (pilot QL)
IL6	B5 · Infrastructure	Digital design software licences are unaffordable	Adapted from Bag et al. (2023)
IL7	B5 · Infrastructure	No shared CFC supports our product development	Adapted from NID (2019)
PE1	B6 · Policy	Government design schemes are hard to apply to	Adapted from Roy & Modak (2026)
PE2	B6 · Policy	Documentation requirements for schemes are excessive	Author-developed (pilot QL)
PE3	B6 · Policy	Industry associations do not advocate DT for MSMEs	Author-developed (pilot QL)
PE4	B6 · Policy	No academia-industry channel exists for DT in our cluster	Adapted from Mair & Marti (2009)
PE5	B6 · Policy	Policy outreach to our cluster is weak	Adapted from Scott (2014)
PE6	B6 · Policy	Subsidy processing times are too long	Author-developed (pilot QL)
MA1	B7 · Measurement	We cannot measure design's impact on sales	Adapted from Borja de Mozota (2003)
MA2	B7 · Measurement	Design-impact indicators are unfamiliar to us	Adapted from Roto et al. (2011)
MA3	B7 · Measurement	Customer satisfaction is not formally tracked	Author-developed (pilot QL)
MA4	B7 · Measurement	We have no design-KPI dashboard	Adapted from Calabretta et al. (2021)
MA5	B7 · Measurement	Design ROI is hard to demonstrate to our owner	Author-developed (pilot QL)

The dependent variable (DT Adoption Intention) was measured using three items adapted from Venkatesh et al. (2003):

- AI1: We intend to adopt Design Thinking methods in our product development within the next 12 months.
- AI2: We plan to invest in design training or external design support in the coming year.
- AI3: We will integrate user-centred problem-solving into our innovation process going forward.