



An Empirical Analysis of Digital Adoption Drivers and Scalability Challenges in Mushroom Processing SMEs

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ABSTRACT

Mushroom Processing SMEs are small and medium enterprises engaged in activities such as cleaning, slicing, drying, canning, and packaging of mushrooms for commercial sale. These units play a vital role in adding value, extending shelf life, and enhancing market reach for mushroom growers.

Purpose: This study investigates how digital tools influence scalability in mushroom processing SMEs in Pune District. It aims to identify the critical drivers and barriers of digital adoption and how these affect operational growth, efficiency, and market expansion in this under-researched Agro-processing sub-sector.

Design/methodology/approach: A mixed-method sequential exploratory design was adopted. Qualitative insights were gathered through semi-structured interviews with 15 SME owners and analysed thematically. These findings informed a structured quantitative survey administered to 105 respondents, analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM). The study integrated the Unified Theory of Acceptance and Use of Technology (UTAUT) and the Technology–Organization–Environment (TOE) framework.

Findings: The study reveals that digital awareness, perceived return on investment (ROI), and traceability adoption significantly affect digital uptake. Digital literacy mediates this relationship, while firm size moderates the impact on business scalability. Qualitative insights highlight resistance due to low awareness and limited digital trust. Quantitative results show strong statistical support for the proposed model

Research limitations/implications: The study is context-specific to mushroom processing SMEs in Pune, limiting generalizability. Further, while mixed methods enrich understanding, resource limitations constrained sample expansion. Future studies may replicate the model across different Agro-processing clusters in India or compare cross-country data.

Practical implications: Findings offer actionable insights for entrepreneurs, policymakers, and ecosystem enablers to improve digital literacy and promote traceability practices. Interventions can include subsidized ERP tools, mobile-based training modules, and targeted digital skilling programs

Originality Value: This paper bridges critical gaps by combining two theoretical frameworks—UTAUT and TOE—in the niche domain of mushroom processing. It is among the first to empirically link digital adoption with scalability outcomes in Indian Agro-processing SMEs, offering new contributions to the field of enterprise digital transformation.

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INTRODUCTION

Mushroom is one of the food delicacies from years and frequently referred to in Greek and Roman. Earlier horse manure was used to cultivate mushrooms, but it was very uncertain. Over the time, this method has been stopped and people started trying to cultivate in synthetic compost and climate-controlled growing environments.

BACKGROUND OF THE STUDY

Mushroom cultivation and processing represent a promising agro-industrial opportunity in India, driven by rich agro-waste availability and favourable agro-climatic conditions. The industry has grown five- to six-fold in recent years, becoming a source of income and employment in rural regions. Despite this growth, many small-scale processors remain technologically unaware and underdeveloped. Large technological gaps persist in production methods—including temperature control, humidity management, and post-harvest drying processes—which negatively affect yield, product quality, and revenue potential. Training programs have shown that targeted capacity-building significantly improves adoption rates of mushroom cultivation best practices. However, adoption of advanced technologies such as traceability systems, digital quality control tools, or automation remains limited due to low awareness, cost concerns, and a lack of technical literacy. Concurrently, global research highlights that small agribusinesses undergo a "technological transformation" process that requires not just tool adoption but also complementary organizational capabilities and business model innovations. In the Indian food SME context, studies underscore barriers—such as infrastructural limitations, financial

constraints, and managerial capability gaps—that seriously inhibit digital adoption. Yet, the specific case of mushroom-processing SMEs remains understudied: their digital maturation is poorly recorded, despite potential for scalable change through technologies like IoT-driven Traceability, ERP systems, and digital quality control tools. This study fills this gap by exploring how digital awareness, perceived return on investment (ROI), and digital literacy influence digital adoption and scalability in this SME sector.

Mushroom Processing SMEs in India

There are various types of mushrooms available in India and abroad. It has been seen that there are 10,000 species of mushrooms available. All are not edible. Let's see some of the prominent mushrooms and their cultivation conditions.

Beech Mushroom: It has an unusual structure which is crunchy and mild in flavour. They grow mostly in East Asia.

White Mushroom (*Agaricus Bisporus*): It is available in more than 70 countries. It is majorly found in Uttar Pradesh, Himachal Pradesh, Punjab. This type is widely grown. It requires a winter season. In some places it is a staple food. This is sold out majorly through E-Commerce having low price differentiation.

Oyster Mushroom: This type of mushroom is available round the year. It grows at 15- 30 degrees. Some call it a Fresh Dhingri often bundled with exotic packs.

Shiitake (*Lentinula edodes*): This mushroom is grown on hardwood. It requires 22–26-degree temperature and 80-to-85-degree humidity. There is a huge market value for this mushroom. It has a

meaty texture and culinary prestige. It extensively grows in the Northeast area. It sold out at premium pricing.

Paddy Straw Mushroom (Volvariella Volvacea): It is a summer species that grows in 28 to 35 degree temperature. Usage: Designed for outdoor cultivation in full-shade environments It is best grown in summer months. It requires a moderate prefers a warm, humid setup. It is Fast-growing summer strain; gluten-free substrate used. It has yellow mycelium-rich spawn. It has Multiple flushes under optimal conditions.

Lions Mane mushrooms: Effortless Cultivation: Lions mushroom spawn seeds allow for hassle-free mushroom cultivation at home or in a controlled environment. These seeds can produce a range of edible mushroom species, including the highly prized. Lions Mane mushrooms are packed with essential nutrients and offer potential health benefits. With proper care and conditions, these spawn seeds ensure consistent and bountiful mushroom yields. Cultivating mushrooms at home using spawn seeds is an eco-friendly and sustainable practice.

Snow Mushroom / White Fungus / Silver Ear Mushroom / Snow Ear: They are jelly like frilly mushrooms used in Chinese cuisine and traditional medicines. They are used in skin hydration, boosting immunity and lung health. Also used in soap, dessert and teas.

RESEARCH GAP AND MOTIVATION

Majority types of Mushrooms are available on e-commerce platforms. But there is less awareness about various types and its benefits among the direct consumers. Whereas pharmaceutical companies are utilising them as an ingredient in various

products. But these Pharma and Beauty or Food and Beverage industries must bring more awareness among the customers about use of Mushroom and its allied products.

Mushrooms are grown in the small scale as well as at the medium scale by small and medium industries. Many are growing it in their small 10/10 area and hoping to get a good demand from the market. But they are facing huge challenges in doing marketing and getting buyers for their mushroom.

Hence, a researcher felt that this gap should be found for giving digital solutions for overcoming scaling challenges in mushroom processing.

RESEARCH PROBLEM

- Mushroom processing industries are facing persistent challenges in scaling operations
- Small farmers of mushroom are not having digital business knowledge
- Mushroom eating habits is not a regular practice in India as of now due to inadequate awareness, lack of ROI clarity, poor digital literacy, and underutilization of traceability/quality control technologies.

RESEARCH OBJECTIVES

- To assess the level of digital awareness and tool adoption among mushroom SMEs.
- To examine how perceived ROI influences the adoption of digital solutions.
- To investigate the impact of traceability and quality control technologies on business scalability.

- To explore the role of digital literacy as a mediating factor between digital tool adoption and business growth.

LITERATURE REVIEW

Digital Transformation in Agro-Food SMEs: In the previous studies (Appel, et al; (2020) stated that social media is very important for SMEs. It bridges a gap between consumer and business (Mason et al., 2021; Appel et al.,2020). Also, the authors opined that the Facebook, Instagram, YouTube, Snapchat and LinkedIn presently stand as the most utilizes social networking sites and which can be highly used to display your products and service. Several studies have highlighted that the implementation of digital transformation (DT) within SMEs often encounters significant organizational and strategic barriers. These limitations arise not only from technological constraints but also from structural inertia, lack of digital competencies, and limited change management capabilities within these firms (Scuotto et al., 2022). While technological tools are increasingly accessible, their mere presence does not guarantee successful transformation unless accompanied by organizational readiness and ecosystem support. Garzoni, A., De Turi, I., Secundo, G. and Del Vecchio, P. (2020), have mentioned four levels of digital transformation like digital awareness, digital requirements, digital collaboration and digital transformation.

Issues and Challenges by Mushroom Growers: There are many challenges and issues are addressed by the growers. Earlier mushrooms were grown in the jungles and villages. That time mushrooms had no value. It was consumed by people from the rural community. However, in recent times, it is

creating a problem of its growing in the artificial environment. The main problems are identified in the Production, Marketing and its government initiatives as per Mohd Tarmizi Haimid et al; (2013). The researcher has asked about the problems of scaling. It has been observed that they are not getting the market as per expectation. When Marketing problems were discussed, the price, product, place, promotion techniques were passed from growers to growers or MCCIA or any other body who are involved in this training process. But growers are still facing many challenges with respect to digital marketing. Digital marketing is vast concept and spending money on this may not fully guarantee that it will give expected Return on Investment.

A researcher has visited 15 growers who are in rural and urban areas having indifferent capacity to produce mushrooms. They were asked.

Mushroom Industry and its Digitization

Potential: The mushroom industry has emerged as one of the most dynamic segments within the horticultural sector, owing to its relatively short production cycle, high nutritional value, and growing consumer preference for plant-based proteins. Globally, the mushroom market is projected to reach USD 86 billion by 2030, driven by demand for functional foods and increased awareness of health benefits (FAO, 2023). In India, mushroom cultivation has witnessed steady expansion, particularly among small and medium enterprises (SMEs) seeking value addition opportunities within the agro-food processing domain. Regions such as Pune district have become notable hubs due to favourable climatic conditions, availability of Agri-residues, and proximity to urban consumption centres.

Despite these advantages, mushroom processing SMEs frequently grapple with challenges related to perishability, quality consistency, and limited market reach. Herein lies a significant untapped potential for digitization, which can address critical bottlenecks across production, processing, and marketing stages. Digital tools such as IoT-enabled climate monitoring systems can optimize temperature and humidity in cultivation chambers, while enterprise resource planning (ERP) systems and blockchain-based traceability solutions can enhance transparency, facilitate compliance with food safety regulations, and bolster consumer trust (Jena et al., 2022).

Moreover, e-commerce platforms and digital market linkages offer avenues for SMEs to transcend local market constraints, directly engaging with institutional buyers and end consumers. However, empirical evidence on the adoption of such digital solutions within the mushroom sector remains sparse, particularly in the context of small-scale enterprises that often lack requisite technical capabilities and investment capital. The integration of digital technologies is further complicated by low levels of managerial digital literacy, concerns over uncertain returns on investment, and fragmented supply chain structures.

Consequently, the mushroom industry represents a fertile ground for studying how targeted digital interventions can simultaneously address operational inefficiencies and unlock new growth trajectories. This study positions itself within this critical intersection, seeking to examine the drivers, barriers, and outcomes of digital adoption, with a particular emphasis on traceability, perceived ROI, and

the mediating role of digital literacy in fostering business scalability.

UTAUT and TOE Frameworks in SME Research: The famous and widely accepted model for the acceptance of technology is UTAUT developed by Venkatesh *et al.* (2003). He had proposed a model for understanding consumer reaction towards Information Technology. Later the role of external variables was removed in the TAM2 model. Perceived usefulness and intention to use has been added with extending a theory. Venkatesh has invented many models to propose technology acceptance. By these models, researcher has adopted a scale to frame qualitative questions.

Challenges of Traceability and ROI in Processing SMEs: Foremost among these challenges is the significant capital investment required to establish traceability infrastructures, such as enterprise resource planning (ERP) systems, blockchain-based ledgers, or advanced QR/Rfid tracking solutions (Ali et al., 2021). For resource-constrained SMEs, these costs often represent a prohibitive barrier. Moreover, the absence of requisite technical expertise within small enterprises further complicates deployment and maintenance, leading to increased reliance on external service providers, which can undermine data security and operational autonomy (Ghosh et al., 2022).

Another critical concern stems from fragmented and informal supply chains, wherein inputs are procured from multiple small-scale producers. This heterogeneity complicates the standardization of data capture and undermines the integrity of traceability records (Zhu et al., 2023). Additionally, data quality issues, arising

from manual record-keeping practices and inconsistent adherence to documentation protocols, reduce the reliability of traceability systems. Regulatory complexities add another layer of difficulty; navigating diverse certification regimes (such as FSSAI, ISO 22000, or GLOBALG.A. P) demands administrative capabilities often beyond the reach of SMEs (Kumar & Sharma, 2020).

ROI Challenges: From an ROI perspective, SMEs frequently exhibit reluctance toward digital investments due to the uncertain and extended payback periods associated with technology adoption (Fernando et al., 2021). Unlike large enterprises that can leverage economies of scale to amortize costs, SMEs operating at lower production volumes struggle to justify expenditures on advanced digital solutions purely from a cost-benefit standpoint.

Moreover, the intangibility of several benefits, such as enhanced brand reputation, improved consumer confidence, or reduced liability risk, poses challenges in quantifying financial returns (Liu et al., 2022). This issue is exacerbated in price-sensitive markets where buyers are unwilling to pay a premium for certified traceable products, thereby limiting the realization of direct economic gains. Additionally, market volatility and stiff competition compel SMEs to prioritize immediate operational survival over long-term digital transformation strategies, adversely affecting investment appetite.

Collectively, these challenges underscore the necessity for targeted policy interventions, capacity-building programs, and incentive mechanisms to support SMEs in overcoming both the technical and

economic barriers to adopting robust traceability systems. They also highlight the critical need for empirical studies examining the nuanced interplay between perceived ROI and actual investment behaviours in small-scale processing industries.

RESEARCH GAP AND THEORETICAL FOUNDATION

While substantial scholarship exists on digital transformation in large-scale agri-food enterprises, there remains a notable paucity of empirical investigations focusing on micro and small processing SMEs, particularly within niche sectors such as mushroom processing. Prior studies predominantly emphasize technological infrastructure and broad adoption metrics, often overlooking context-specific constructs such as perceived ROI, traceability imperatives, and the mediating role of digital literacy (Ghosh et al., 2022; Liu et al., 2023). Moreover, scant attention has been paid to how these factors collectively influence business scalability in resource-constrained environments. This study addresses this lacuna by integrating behavioural and organizational perspectives through an enriched theoretical framework combining UTAUT and TOE, thereby providing a holistic understanding of technology adoption dynamics in mushroom SMEs.

THEORETICAL FRAMEWORK AND HYPOTHESES

Justification for Framework Selection

To comprehensively investigate the multifaceted determinants of digital tool adoption and their subsequent impact on

business growth, this study synthesizes the Unified Theory of Acceptance and Use of Technology (UTAUT) and the Technology-Organization-Environment (TOE) framework. The integration of these models allows simultaneous examination of individual behavioural drivers (as explicated by UTAUT) and broader organizational-contextual factors (captured by TOE), offering a robust lens for understanding technology adoption in small processing enterprises.

Unified Theory of Acceptance and Use of Technology (UTAUT)

The UTAUT model (Venkatesh et al., 2003) posits that performance expectancy, effort expectancy, social influence, and facilitating conditions significantly determine users' behavioural intention to adopt technology. Within the context of mushroom SMEs, perceived ROI can be conceptualized as an extension of performance expectancy, directly influencing managers' willingness to embrace digital traceability and quality control tools. Likewise, digital literacy levels serve as critical facilitating conditions, potentially moderating the ease with which such technologies are assimilated into routine operations.

Technology-Organization-Environment (TOE) Framework

Complementing UTAUT, the TOE framework (Tornatzky & Fleischer, 1990) emphasizes how technological readiness, organizational characteristics, and environmental pressures shape technology adoption decisions. For mushroom SMEs, technological factors include the availability and perceived compatibility of digital solutions, organizational factors encompass firm size, managerial capability, and strategic orientation, while environmental pressures

manifest through regulatory standards and market demands for traceability. This framework thus contextualizes individual adoption attitudes within the structural realities faced by SMEs.

Integration and Conceptual Model

By integrating UTAUT and TOE, this study develops a composite conceptual model wherein:

Perceived ROI (from UTAUT's performance expectancy) and technological/organizational/environmental contexts (from TOE) jointly influence the adoption of digital solutions.

Traceability and quality control technologies are posited as direct antecedents to business scalability, reflecting operational improvements and market competitiveness.

Digital literacy functions as a mediating variable, shaping how effectively digital adoption translates into scalable business outcomes.

This integrative framework offers a nuanced perspective, bridging micro-level behavioural insights with macro-level organizational contingencies.

HYPOTHESES DEVELOPMENT

Based on the above theoretical synthesis, the following hypotheses are proposed:

H1: Perceived ROI positively influences the adoption of digital solutions in mushroom SMEs.

H2: Technological, organizational, and environmental contexts significantly influence the adoption of digital traceability and quality control tools.

H3: Adoption of digital traceability and quality control technologies positively

impacts the scalability of mushroom processing businesses.

H4: Digital literacy mediates the relationship between digital solution adoption and business scalability.

RESEARCH METHODOLOGY

Research Paradigm: Pragmatism
This study is underpinned by a pragmatic research paradigm, which emphasizes practical solutions to complex, context-specific problems by leveraging both qualitative and quantitative approaches (Creswell & Plano Clark, 2017). Pragmatism is particularly well-suited to research inquiries that intersect human perceptions (e.g., perceived ROI, digital literacy) with organizational and technological contexts (as articulated in the TOE framework), and that seek to understand actionable pathways for enhancing business scalability.

The pragmatic stance enables the researcher to prioritize the research problem over methodological allegiance, thus allowing for methodological pluralism. In the context of this study, pragmatism supports the integration of qualitative insights to uncover nuanced barriers and drivers of technology adoption, alongside quantitative assessment to examine relationships among key constructs identified through the integrated UTAUT-TOE framework.

RESEARCH DESIGN

An exploratory-descriptive design was adopted, appropriate for investigating relatively under-researched domains such as digital transformation within mushroom processing SMEs. This design facilitated an initial qualitative exploration to uncover thematic dimensions, followed by a

structured quantitative component to validate hypothesized relationships.

Research Methods Justification

A researcher has used a qualitative method to collect data. It supports four reasons 1. Naturalism 2. Ethnomethodology 3. Emotionalism 4. Postmodernism. The reason behind using this method is, mushroom experience of each farmer/ small scale business owner is different. The level of problems and challenges are different. Hence, collecting their opinion was very important to explore the issues that persist in this industry.

Sampling and Data Sources

The study employed a sequential exploratory approach. For the qualitative phase, 15 mushroom growers were purposively sampled to ensure diversity in scale, technological exposure, and market orientation. Their perspectives were gathered through semi-structured interviews, transcribed and analysed in NVivo to extract key themes.

For the quantitative phase, a structured survey was administered to 105 mushroom SMEs selected through stratified random sampling from local industry directories and cooperatives. This ensured proportional representation across firm sizes, facilitating robust PLS-SEM analysis of the hypothesized relationships.

QUALITATIVE ANALYSIS

The transcribed interviews were imported into NVivo 14 for systematic qualitative analysis. An inductive thematic coding approach was employed, beginning with open coding to identify recurrent concepts related to digital awareness, perceived ROI, traceability practices, and scalability challenges. Axial coding was then used to establish connections

among these categories, allowing for the emergence of higher-order themes.

To ensure rigor and reliability, peer debriefing was conducted with two independent researchers who reviewed a subset of coded transcripts, leading to minor refinements in the coding scheme. Data saturation was confirmed when no new themes emerged from the final interviews. Analytical memos were maintained throughout the process to capture interpretative reflections and strengthen the transparency of analytical decisions.

Ethical Considerations: Ethical approval was obtained from the institutional review board. Participants were provided with informed consent statements ensuring confidentiality and the right to withdraw at any stage. Data was anonymized and securely stored, in line with GDPR-aligned practices.

TYPES OF VARIABLES

In line with the integrated UTAUT and TOE frameworks, this study explored key constructs such as perceived ROI, technological, organizational, and environmental factors, digital literacy, and business scalability. These were first identified qualitatively and then operationalized into multi-item Likert scales for quantitative validation.

Perceived ROI: understood as managers' expectations of operational and financial benefits from adopting digital solutions (UTAUT's performance expectancy).

Technological, organizational, and environmental factors: reflecting TOE's dimensions, including digital readiness, managerial expertise, and external market or regulatory pressures.

Digital literacy: examined as a critical competence shaping the ability to leverage digital tools.

Business scalability: conceptualized through narratives of expanding production, entering new markets, or diversifying products.

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