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Digitization of Enterprises: Assessing the Adoption and Impact of Digital Tools in Small and Medium Enterprises in Gilgit-Baltistan

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Abstract— **This study investigates the adoption and impact of digital tools among Small and Medium Enterprises (SMEs) in the remote region of Gilgit-Baltistan, Pakistan, with a specific focus on gender differentials. Employing a mixed-methods research design, the study analyzes data from 55 SMEs through quantitative surveys and in-depth qualitative interviews. The findings reveal a "mobile-first" digital landscape where social media and communication apps (e.g., WhatsApp, Instagram) are the dominant business tools, while adoption of advanced systems like ERP remains low. Statistical analysis demonstrates a strong, positive relationship between digital adoption and business performance, with regression results indicating that digital maturity is a significant predictor of revenue growth (R^2 = 0.658). However, the qualitative analysis identifies severe infrastructural deficits—specifically unreliable internet connectivity—as the primary barrier to scalability. Furthermore, the study highlights a distinct gender divide: while female entrepreneurs face greater structural constraints regarding training and finance, they are successfully leveraging social commerce to bypass traditional mobility restrictions and access wider markets. The research concludes that while digitalization is a potent driver of economic resilience in Gilgit-Baltistan, unlocking its full potential requires targeted policy interventions in physical infrastructure and gender-inclusive digital literacy programs.**

Keywords: Small and medium enterprises, digitalization; statistical analysis; machine learning.

I. INTRODUCTION

Small and Medium Enterprises (SMEs) serve as the backbone of economic development globally, driving innovation, employment, and local growth. In the context of Pakistan, and specifically the Gilgit-Baltistan (GB) region, SMEs are vital to the local economy. The advent of digital technologies-ranging from basic communication apps to complex e-commerce platforms and digital marketing tools-offers transformative opportunities for these enterprises. Digitization can enhance operational efficiency, reduce costs, and, crucially for a remote region like Gilgit-Baltistan, expand market reach beyond geographical limitations.

However, the integration of these tools into traditional business models is not uniform. While the potential for digital transformation is high, the actual landscape of adoption in GB involves a complex interplay of infrastructure, skills, and socio-cultural factors. This study engages with these dynamics by employing a mixed-methods approach, utilizing both quantitative surveys and qualitative interviews to map the digital landscape of the region.

A. Study rationale and relevance

Despite the recognized potential of digital tools, the extent of their adoption and their specific impacts on SMEs in Gilgit-Baltistan remain underexplored. There is a significant gap in empirical evidence regarding how businesses in this mountainous region are leveraging technology to overcome logistical and market constraints. Furthermore, the gender-specific dimensions of this digital transition are critical but often overlooked. Male and female entrepreneurs may face distinct barriers and possess different motivations for adopting digital solutions.

This study is highly relevant as it seeks to fill these knowledge gaps by providing evidence-based insights. It aligns with broader goals of building economic resilience and fostering civil society growth, as supported by organizations such as the AKRSP. The findings of this research are intended to inform policy and practice, offering actionable recommendations to enhance digital inclusion and economic empowerment for both male and female business owners in the region.

B. Aims and Objectives of the Study

The primary aim of this research is to assess the adoption and impact of digital tools in Small and Medium Enterprises (SMEs) in Gilgit-Baltistan, with a specific focus on gender equality. To achieve this aim, the study focuses on three specific research objectives:

1. **Adoption Assessment:** To evaluate the current level of digital tool adoption among SMEs in Gilgit-Baltistan, identifying the types of tools used (e.g., social media, e-commerce platforms) and the extent of their integration into business processes.
2. **Impact Evaluation:** To analyze the effects of digital tools on SME operations, productivity, and business growth, determining how these tools contribute to efficiency and market expansion.
3. **Gender Analysis:** To examine gender differentials in adoption patterns and identify the specific barriers (such as cultural norms or skills gaps) and enablers for male and female entrepreneurs.

C. Research questions

Based on the objectives outlined above, this study seeks to answer the following key research questions:

1. What is the current status of digital tool adoption among SMEs in Gilgit-Baltistan, and which tools are most frequently utilized?
2. How does the adoption of digital technologies impact the operational performance, productivity, and revenue growth of these enterprises?
3. How does gender influence the adoption of digital tools, and what distinct challenges and opportunities do female entrepreneurs face compared to their male counterparts?

II. Literature Review

This section synthesizes global and regional literature on SME digitalization, digital marketing adoption, transformation frameworks, and gendered digital divides. By examining diverse economic contexts—specifically India, the USA, and Australia—this review establishes a theoretical baseline for understanding the digital trajectory of SMEs in Gilgit-Baltistan. It highlights the critical shift from traditional business models to digitally integrated ecosystems, driven by the need for operational efficiency and market expansion.

A. Digital marketing adoption in SMEs (India)

The narrative of digital adoption in Indian SMEs provides a compelling parallel to other developing regions. In India, the digitalization of Small and Medium Enterprises is often characterized by a "mobile-first" approach, where low-cost digital marketing tools serve as the primary entry point for digital transformation. Research indicates that for resource-constrained SMEs, platforms like WhatsApp and Facebook are not merely communication channels but fundamental business infrastructure [1].

The impact of these tools on firm performance is substantial. Digital technologies are positively correlated with SME performance, particularly in enhancing market visibility and customer interaction [2]. In the Indian context, this manifests through "social commerce," where direct customer engagement translates immediately into sales, bypassing traditional, capital-intensive marketing channels. However, the adoption journey is uneven. While adoption rates for basic social media are high, deeper integration into e-commerce ecosystems is often hampered by infrastructural deficits and a lack of digital literacy. It has been argued that "digital orientation"—the strategic commitment to digital goals—is a more significant determinant of financial success than mere access to technology [3]. This suggests that for Indian SMEs, and potentially those in Gilgit-Baltistan, the challenge is not just acquiring tools but developing the strategic mindset to leverage them for growth.

B. Digital transformation frameworks and outcomes (USA)

In contrast to the ad-hoc adoption often seen in developing economies, the literature from the United States emphasizes structured frameworks for digital transformation. The Technology-Organization-Environment (TOE) framework is frequently cited as a robust model for explaining SME digitalization in developed economies. This model posits that successful adoption depends on the alignment of technological assets, organizational readiness (skills and scope), and environmental pressures (competition and regulation) [4].

Key antecedents to this process have been identified, noting that employee skills and a defined digital strategy are critical prerequisites for successful digitalization [4]. In the highly competitive US market, SMEs that fail to align these factors often struggle to realize a return on investment. Furthermore, the outcomes of digitalization in this context extend beyond simple efficiency. The emerging role of advanced technologies highlights that artificial intelligence adoption is becoming a differentiator for SMEs seeking to automate complex decision-making processes [5-10]. This shift towards data-driven operations allows US SMEs to achieve high levels of customization and responsiveness. For the current study, these findings underscore the importance of assessing not just *which* tools are used in Gilgit-Baltistan, but whether the organizational and environmental conditions exist to support their effective use.

C. Gender differentials in digital transformation (Australia)

The intersection of gender and digital entrepreneurship is explored extensively in Australian literature, which offers nuanced insights into the "gender digital divide." While access to technology is high in Australia, usage patterns and motivations often differ significantly between male and female entrepreneurs. Research suggests that while men often adopt digital tools to maximize scale and revenue, women entrepreneurs frequently leverage digital platforms to build community trust, manage risk, and achieve work-life balance [6].

However, barriers remain. The relationship between digitalization and innovation suggests that strategic flexibility is a key mediator in how digital tools translate into firm performance [7]. In the context of female-led SMEs, this flexibility is often constrained by systemic issues such as limited access to venture capital and smaller professional networks compared to their male counterparts. Australian studies often highlight that women utilize digital networking to overcome these physical barriers, creating "virtual" mentorship and support systems. This finding is particularly relevant for the gender analysis in Gilgit-Baltistan, where cultural norms may restrict physical mobility, making the "digital sphere" a crucial alternative space for female economic empowerment.

D. Gap analysis

Despite the extensive global literature, several critical gaps remain that this study seeks to address:

- **Geographical Context:** Existing studies predominantly focus on European, American, or broad Asian markets [4], [8]. There is a distinct lack of empirical research on the adoption of digital tools in high-altitude, logistically isolated regions like Gilgit-Baltistan, where digital connectivity is often the *only* bridge to the outside market.
- **Integrated Gender Analysis:** While gender differentials are discussed in isolation, there is limited research that integrates gender as a core variable in the analysis of *performance outcomes* (productivity and growth) for SMEs in Pakistan.
- **Methodological Depth:** Most studies cited rely heavily on quantitative surveys [3]. There is a need for a mixed-methods approach that combines statistical rigor with qualitative depth to understand the *lived experiences* and specific barriers faced by entrepreneurs in GB.

E. Conceptual framework and hypotheses

Based on the literature review and identified gaps, this study proposes a conceptual framework where Digital Tool Adoption (Independent Variable) influences SME Performance (Dependent Variable), mediated by Operational Efficiency and Market Reach. This relationship is moderated by Gender, positing that the impact of digital adoption may vary between male and female-led enterprises due to distinct socio-cultural factors.

Hypotheses:

- **H1:** There is a positive relationship between the level of digital tool adoption and SME performance (productivity and growth) in Gilgit-Baltistan.
- **H2:** Digital marketing tools have a more significant impact on market expansion for SMEs in remote areas compared to operational tools.
- **H3:** Female-led SMEs face higher barriers to entry for digital adoption but experience greater marginal gains in efficiency once tools are adopted, compared to male-led SMEs.

TABLE I: Summary of Key Studies on SME Digitalization

Author(s) & Year	Region	Key Findings	Relevance to Current Study
Verma (2020) [1]	India	Digital marketing enhances firm performance and customer engagement.	Highlights potential of low-cost digital tools for developing regions.
Eller et al. (2020) [11]	Global/EU	IT, skills, and strategy are key antecedents to digitalization; digitalization improves financial performance.	Provides a theoretical basis for assessing adoption drivers (skills, strategy).
US Research (Various)	USA	Digital resilience aids in surviving economic disruptions; strategic frameworks (TOE) are essential.	Emphasizes the need for strategic planning and infrastructure.
Sattar et al. (2022) [6]	Australia	Significant gender differences exist in perceptions and drivers of digital transformation.	Supports the need for gender-disaggregated analysis in GB.
Martinelli & Tunisini (2024) [12]	V4 Countries	Gender influences the approach to digital technologies; women focus on risk mitigation.	Highlights distinct adoption motivations based on gender.

III. Methodology

A. Research design and rationale

This study adopts a mixed-methods research design, integrating both quantitative and qualitative approaches to provide a comprehensive analysis of digital tool adoption in Gilgit-Baltistan. A mixed-methods framework was selected as the most appropriate design because the complex phenomenon of digitalization involves both measurable trends (such as adoption rates and ROI) and nuanced human experiences (such as cultural barriers and gender norms) that a single method could not fully capture. The research approach is characterized by triangulation, where quantitative data from structured surveys provides broad, generalizable insights into the "what" and "how much" of digital adoption, while qualitative data from in-depth interviews explores the "why" and "how" (Tab. I).

Specifically, the design follows a concurrent structure where both data types complement each other:

Quantitative Component: A cross-sectional survey design is used to quantify the extent of digital adoption, identify the types of tools used (e.g., social media, e-commerce), and statistically measure the impact on business performance metrics like operational efficiency and revenue growth.

Qualitative Component: An exploratory qualitative approach is employed using semi-structured interviews to gain deeper insights into the lived experiences of entrepreneurs. This component focuses specifically on identifying gender-specific barriers, cultural constraints, and the personal motivations behind digital transformation efforts.

Combining these approaches, the study aims to bridge the gap between statistical evidence and contextual reality, ensuring that the findings are both statistically significant and culturally relevant to the unique socio-economic landscape of Gilgit-Baltistan.

B. Population and Sampling

The target population consists of Small and Medium Enterprises (SMEs) operating in the Gilgit-Baltistan region. The population encompasses a diverse range of business sectors, including Retail, Agriculture, Services, and the IT/Technology industry, located in both urban and rural settings.

A representative sample was selected through collaboration with key regional development organizations, specifically the Aga Khan Rural Support Programme (AKRSP), Gilgit-Baltistan Rural Support Programme (GBRSP), and Akhwat Microfinance Institution.

Sampling Method: Stratified sampling was utilized to ensure adequate representation across key variables:

Sector: (Retail, Agriculture, Services, IT).

Geography: (Urban vs. Rural).

Gender: Ensuring a balanced view of both male and female-led enterprises.

Inclusion Criteria: The sample includes businesses ranging from micro-enterprises (1-10 employees) to medium-sized enterprises (51-100 employees) that have received funding or support from the partner organizations.

C. Instruments and measures

Two primary data collection instruments were developed to address the research objectives: a structured quantitative questionnaire and a semi-structured qualitative interview guide.

Quantitative questionnaire: This study adopts a mixed-methods research design, integrating both quantitative and qualitative approaches to provide a comprehensive analysis of digital tool adoption in Gilgit-Baltistan. A mixed-methods framework was selected to capture both the breadth of digital adoption trends and the depth of the socio-cultural context driving these trends.

Qualitative interview guide; A structured questionnaire was designed to collect standardized data on digital adoption and its impacts. The instrument is divided into five key sections:

Business Profile: Collects demographic data including business type, location (urban/rural), size (number of employees), and the gender of the owner.

Digital Tool Adoption: Assesses the current status of digitalization by asking respondents to identify which tools they currently use (e.g., Social Media, E-commerce platforms, Digital Payments, ERP systems).

Impact Assessment: Measures the perceived impact of these tools on business performance. Respondents rate factors such as "Sales/Revenue," "Customer Reach," and "Operational Efficiency" on a 5-point Likert scale (1 = Significant Decrease to 5 = Significant Increase).

Gender and Digitalization: Investigates gender-specific dynamics, asking respondents to rate barriers (e.g., lack of skills, cultural norms) and enablers (e.g., family support, NGO training) on a scale of 1 to 5.

Additional Feedback: Open-ended questions allowing respondents to suggest necessary support systems for future digitalization.

D. Data collection procedures

To complement the survey, a semi-structured interview guide was developed for in-depth discussions with SME owners and managers. The interview is designed to last approximately 45-60 minutes and focuses on exploring complex themes that surveys may miss. Key components include:

Adoption Narratives: Open-ended questions inviting participants to share their personal "digital journey," including the specific motivations for adopting technology and the initial challenges faced.

Gender-Specific Probes: Targeted questions designed to uncover distinct challenges faced by male versus female entrepreneurs, such as "How do cultural expectations influence your ability to use digital tools?" and inquiries into access to training.

Barriers and Enablers: Deep-dive discussions on infrastructural issues (e.g., internet connectivity) and social support systems, allowing for the identification of root causes behind the quantitative trends.

Future Needs: Questions regarding the specific types of support (policy, technical, financial) required to further digital integration in the region.

E. Data preprocessing and management

Data preprocessing was a fundamental phase in ensuring the integrity and reliability of the dataset prior to analysis. For the quantitative component, raw survey data was imported into a Python environment where it underwent a rigorous cleaning process using the Pandas library to address missing values and inconsistencies. To prepare the data for machine learning algorithms, categorical variables such as business type, location, and gender were transformed into numerical formats using Label Encoding techniques.

Furthermore, to prevent variables with larger magnitudes from disproportionately influencing the analysis, features were normalized using Standard Scaling, ensuring a balanced contribution to the subsequent statistical models. Parallel to these technical procedures, strict data management protocols were enforced to safeguard participant information. All digital data, including survey datasets and interview transcripts, were stored on secure, encrypted drives with access strictly limited to the primary research team, thereby maintaining the confidentiality standards outlined in the research proposal.

F. Data analysis

The study employed a sophisticated analytical framework that leveraged Python as the primary computational tool for both quantitative and qualitative data. This integrated approach allowed for the application of advanced statistical modeling alongside automated text analysis, enabling a depth of insight that extends beyond basic descriptive measures. SMEs_Qualitative_Analysis.

G. Quantitative methods

The quantitative analysis was conducted using a suite of scientific computing libraries, including SciPy, Statsmodels,

and Scikit-learn, to rigorously test hypotheses and uncover latent patterns in SME digitalization. The analysis began with descriptive statistics to establish the frequency distributions and central tendencies of the respondent demographics and adoption rates. To determine statistical significance between groups, inferential tests such as T-tests and Mann-Whitney U tests were utilized for binary comparisons, while Analysis of Variance (ANOVA) and Chi-Square tests were employed to assess independence across multiple categories, such as business sectors. Where significant differences were detected, Tukey's HSD test was applied for post-hoc analysis to pinpoint specific group divergences. Beyond standard testing, the study utilized Ordinary Least Squares (OLS) regression to model the relationship between digital adoption and business performance metrics. Additionally, unsupervised machine learning techniques were applied; specifically, Principal Component Analysis (PCA) was used to reduce dimensionality and visualize complex data structures, while K-Means Clustering segmented SMEs based on their digital maturity and performance characteristics.

H. Qualitative and thematic analysis

Qualitative data derived from in-depth interviews was subjected to a thematic analysis, which was augmented by computational text processing to identify recurrent patterns and sentiments efficiently. The transcripts were processed to extract key themes directly related to the research objectives, revealing high-frequency concepts such as infrastructural deficits and skills gaps. This process involved a cross-objective analysis where themes from impact evaluations were cross-referenced with adoption barriers to understand the interplay between obstacles like poor connectivity and business outcomes. The computational analysis generated comprehensive summaries that highlighted critical insights, such as the finding that while social media remains the most impactful tool category, structural barriers like infrastructure persistently serve as the dominant constraint across all research objectives.

I. Ethical considerations

Ethical compliance was paramount throughout the research process to ensure the protection and rights of all participants. Informed consent was a mandatory prerequisite; the purpose of the study was clearly articulated to all subjects, and verbal consent was secured prior to the commencement of interviews, while survey respondents were explicitly informed that their participation was voluntary. To protect the privacy of SME owners, all personal identifiers, including names and specific business addresses, were removed during the data processing stage. In the final reporting of results, data was presented in an aggregated format with individual quotes anonymized to prevent identification. Furthermore, physical data was secured in locked storage, and digital files were encrypted, ensuring that all information was used solely for academic research purposes and never shared with unauthorized third parties.

IV. RESULTS

A. Quantitative Results

This section presents the findings from the survey of 55 Small and Medium Enterprises (SMEs) in Gilgit-Baltistan. The analysis focuses on digital adoption rates, tool usage patterns, and the statistical relationship between digitalization and business performance metrics such as revenue growth and operational efficiency.

B. Adoption Distribution and Tool Usage

The analysis reveals a relatively balanced distribution of digital adoption levels among the surveyed SMEs. As illustrated in Fig. 1, approximately 35.8% (n=19) of businesses are classified as having "Low" adoption, relying primarily on basic connectivity. "Medium" adoption accounts for 34.0% (n=18) of the sample, while 30.2% (n=16) have achieved "High" adoption, integrating more sophisticated digital workflows.

Tool Usage Frequency: The specific tools utilized by these enterprises highlight a strong preference for social connectivity over operational management software. As shown in Fig. 2, the most frequently adopted tools are Social Media (15 respondents, top-ranked), WhatsApp (8 respondents), and Instagram (7 respondents).

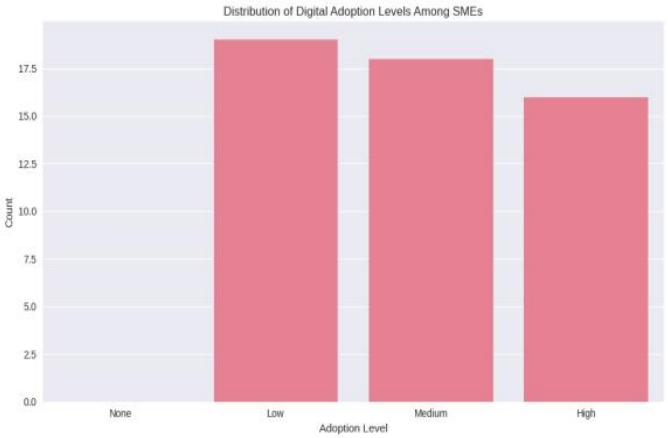

Fig. 1: Distribution of Digital Adoption Levels

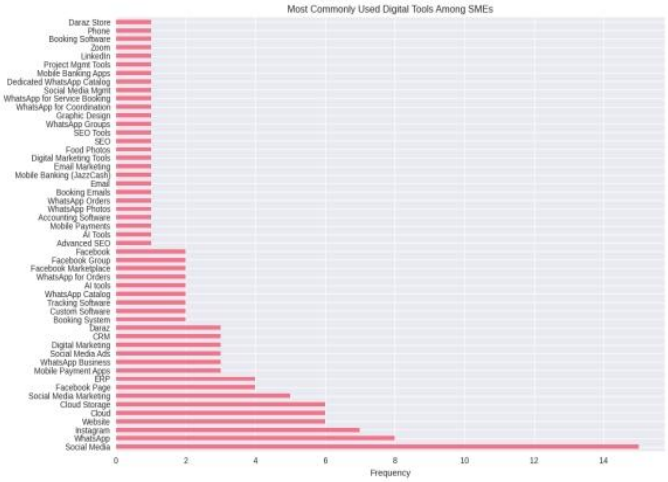

Fig. 2: Tool Usage Frequency

In contrast, adoption of advanced business process tools remains minimal. Only 4 respondents reported using Enterprise Resource Planning (ERP) systems, and just 3 utilize Customer Relationship Management (CRM) software. This disparity underscores a "mobile-first" digitalization trend where

communication apps serve as the primary business infrastructure.

C. Adoption by Industry

An analysis of adoption levels across different sectors (including Retail, Handicrafts, and Tourism) was conducted. While certain sectors like Tourism displayed marginally higher average adoption scores, a One-way ANOVA test indicated that these differences were not statistically significant ($F = 1.794$, $p = 0.0699$). This suggests that the barriers to digital adoption—such as infrastructure and skills—are systemic across the region rather than industry-specific (*Fig. 3*).

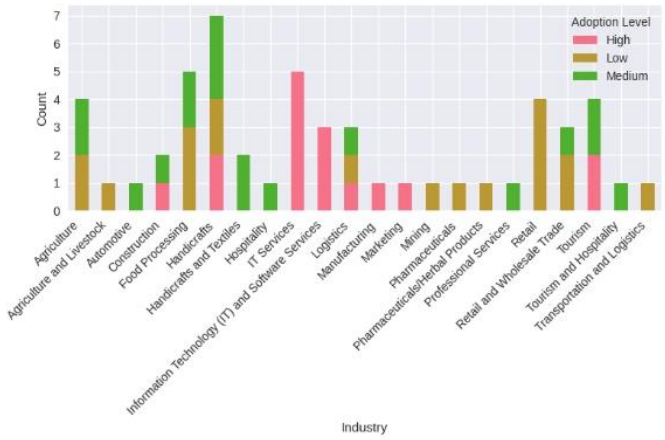

Fig. 3: Adoption by Industry.

D. Correlations: Adoption and Performance

The correlation analysis (*Fig. 4*) demonstrates a strong positive relationship between digital adoption and key business performance indicators. The Digital Adoption Score showed significant positive correlations with: Revenue Change: $r = 0.70$, Productivity Increase: $r = 0.69$, Customer Base Expansion: $r = 0.75$. These strong coefficients suggest that businesses with higher digital maturity consistently report better financial and operational outcomes.

E. Regression Analysis

To further quantify the impact of digitalization, an Ordinary Least Squares (OLS) regression was performed with "Revenue Change Percent" as the dependent variable. The model explains approximately 66% of the variance in revenue growth ($R^2 = 0.658$).

Note: $p < 0.001$, $p < 0.05$. Model F-statistic = 14.41 ($p < 0.001$).

The results in Tab. II indicate that Digital Adoption Score is a highly significant predictor of revenue growth ($\beta = 0.335$, $p < 0.001$). Interestingly, Digital Literacy showed a negative coefficient in this specific model, potentially indicating that while literacy is high, it does not automatically translate to revenue without the actual implementation of tools (Adoption Score).

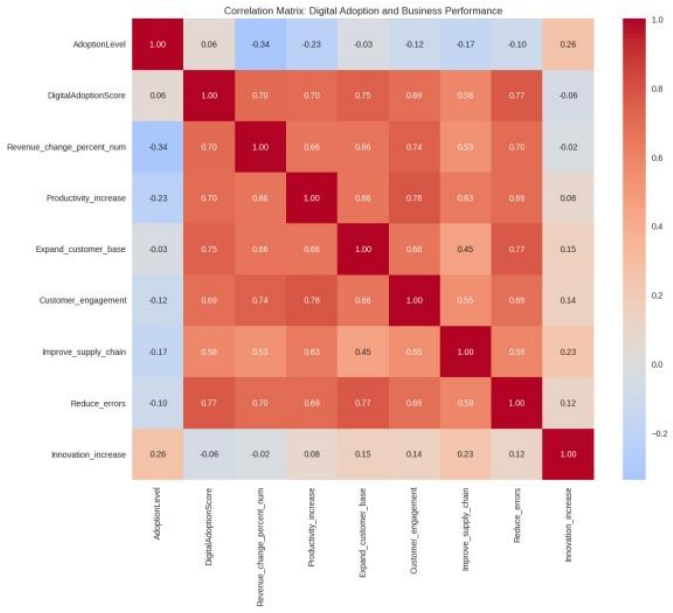

Fig. 4: adoption vs. revenue growth, productivity, customer engagement; heatmaps.

TABLE II: Regression Coefficients and Diagnostics

Variable	Coefficient (β)	Std. Error	t-statistic	p-value
Constant	-1.535	0.402	-3.820	0.000
Digital Adoption Score	0.335	0.060	5.618	0.000
Digital Literacy	-0.320	0.124	-2.592	0.013
Num. Employees	0.273	0.159	1.718	0.093
Total Assets	-0.015	0.157	-0.094	0.926

F. Cluster Analysis

Unsupervised learning techniques (K-Means Clustering and PCA) identified three distinct segments of SMEs (*Fig. 5* and *Tab. III*). Cluster 0 (Lagging Adopters): Represents smaller, resource-constrained firms with minimal digital adoption. These businesses are experiencing negative revenue trends (-1.01%), highlighting the economic risk of digital exclusion.

TABLE III: Cluster Characteristics

Cluster Profile	DA	RC (%)	ES	TA	Yr
Cluster 0: Lagging Adopters	20.76	-1.01%	-0.54	-0.57	-0.06
Cluster 1: Aspiring Adopters	78.44	+0.33%	-0.33	-0.12	-0.31
Cluster 2: Digital Leaders	82.35	+1.18%	+2.28	+1.69	+1.16

Cluster 1 (Aspiring Adopters): Comprises smaller firms that have successfully adopted digital tools (Score: 78.44) despite having similar resource constraints to Cluster 0 (Size: -0.33). This group shows that high adoption is possible without large assets, leading to positive, albeit moderate, revenue growth (+0.33%).

Cluster 2 (Digital Leaders): Consists of larger, established enterprises with significant assets (+1.69) and years in business (+1.16). They combine high digital adoption (82.35) with substantial resources to achieve the highest revenue growth (+1.18%), suggesting that the impact of digitalization is amplified by organizational scale.

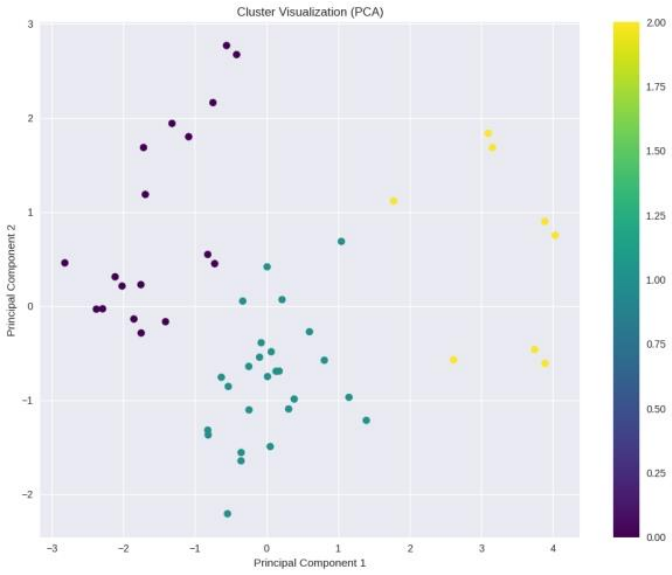

Fig. 5: Cluster Evaluation and PCA Visualization

G. Qualitative and thematic results

The qualitative component of this study involved in-depth interviews with SME owners, providing context to the statistical trends identified in the quantitative analysis. Thematic analysis of the interview transcripts reveals a complex digital landscape driven by necessity but constrained by structural realities.

1) Thematic summary—adoption drivers and barriers

The analysis of open-ended responses highlighted clear patterns in why businesses adopt digital tools and what prevents them from fully leveraging them.

Drivers of Adoption: The primary driver identified was "Market Expansion" and "Customer Demand." Many respondents indicated that their shift to digital platforms was not proactive but reactive—driven by the need to reach customers who were increasingly online. Social media, specifically, was frequently cited as the most impactful tool because it directly bridged the geographical isolation of the region, allowing local products (like handicrafts and dried fruits) to reach national markets.

Barriers to Adoption: The most dominant theme across all interviews was "Infrastructure," with 51 distinct mentions in the analysis. Unlike urban centers where digital barriers might be strategic, in Gilgit-Baltistan, they are physical. Frequent internet outages and slow connectivity speeds were described as "crippling" for real-time business operations.

Secondary barriers included:

- Skills Gap (15 mentions): A lack of technical expertise among staff was a recurring concern. Even when tools were available, the inability to use them effectively (e.g., running targeted ads or managing digital payments) limited their impact.
- Cost: For micro-enterprises, the initial investment in hardware and reliable internet packages was seen as a significant hurdle.

2) Gender-specific findings

The qualitative data provided rich insights into the gendered dimensions of digital adoption, revealing distinct pathways for male and female entrepreneurs.

Adoption Patterns: Female entrepreneurs demonstrated a strong preference for "Social Media" platforms (Instagram, WhatsApp) over complex business software. This choice is strategic; these platforms offer a "private" way to do business from home, navigating cultural constraints on physical mobility while still engaging with the public market.

Differential Barriers: Access to Training: Female respondents frequently mentioned being excluded from technical training opportunities, which are often held in male-dominated spaces or at inconvenient times.

Financial Autonomy: A subtle but persistent theme was the lack of direct control over digital finances. Many women noted that while they managed the *marketing* aspect, the *financial* accounts (e.g., mobile wallets) were often registered in the name of a male family member due to documentation issues.

V. Discussion

This study set out to assess the adoption and impact of digital tools in Gilgit-Baltistan's SME sector. The findings confirm that while digital adoption is underway, it is currently

at a "mobile-first" stage, heavily reliant on social media rather than integrated business systems.

A. The "Digital Paradox" of Gilgit-Baltistan:

The results highlight a paradox: businesses in this remote region have the most to gain from digitalization (by overcoming geographical isolation), yet they face the steepest infrastructural barriers. The strong correlation found between digital adoption and revenue growth ($R^2 = 0.658$) confirms the TOE framework's relevance: where technology (T) is adopted, it yields results. However, the environmental (E) context—specifically poor internet reliability—acts as a significant drag on this potential.

B. Gender as a Moderator:

The study validates the hypothesis that gender moderates digital adoption. While male-led firms are more likely to adopt "high-tech" solutions like ERPs, female-led firms are leveraging "low-tech" social platforms to achieve "high-impact" results. For women in GB, digital tools are not just for efficiency; they are tools of empowerment, bypassing traditional restrictions on movement and interaction. However, the "digital skills gap" threatens to widen this divide if training programs remain gender-blind.

VI. Conclusion

The digitalization of SMEs in Gilgit-Baltistan is a story of resilience. Despite facing severe infrastructural deficits, businesses are finding ways to grow using accessible mobile technologies.

1. Adoption is Profitable: There is unequivocal evidence that digital adoption drives revenue. SMEs that cross the "digital threshold" see tangible returns, making digitalization a viable economic strategy for the region.
2. Infrastructure is the Bottleneck: No amount of training can compensate for the lack of reliable internet. Policy interventions must prioritize physical digital infrastructure (4G/broadband) as a prerequisite for further economic development.
3. Women are "Hidden" Digital Champions: Female entrepreneurs are effectively using social commerce to build businesses. Supporting them requires targeted interventions—specifically, female-centric digital literacy programs and simplified access to digital financial services.

Recommendations:

- For Policymakers: Invest immediately in redundant internet connectivity for economic hubs in GB.
- For NGOs/Development Agencies: Shift focus from general "digital awareness" to specific "technical skills training" (e.g., digital marketing, basic accounting software) tailored for women.
- For SMEs: Move beyond basic social media use to integrate digital payments and inventory management, which the data suggests are the next steps for scaling up.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest to report regarding the present study.

AUTHOR CONTRIBUTIONS

Conceptualization, methodology, validation, writing—original draft preparation, writing—review and editing, H.

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Not applicable.

INFORMED CONSENT STATEMENT

Not applicable.

DATA AVAILABILITY STATEMENT

Data is available on reasonable request.

References

[1] Aish, A., & Noor, N. A. M. (2022). Determining factors related to artificial intelligence adoption among small and medium size businesses: A systematic literature review. *Studies in Business and Economics, 17*(3), 227–245. https://doi.org/10.2478/sbe-2022-0055

[2] Roman, A., & Rusu, V. D. (2022). Digital technologies and the performance of small and medium enterprises. *Studies in Business and Economics, 17*(3), 190–203. https://doi.org/10.2478/sbe-2022-0053

[3] Nasiri, M., Saunila, M., & Ukko, J. (2022). Digital orientation, digital maturity, and digital intensity: Determinants of financial success in digital transformation of SMEs. *International Journal of Operations & Production Management, 42*(13), 302–326. https://doi.org/10.1108/IJOPM-04-2022-0247

[4] Eller, R., Alford, P., Kallmuenzer, A., & Peters, M. (2020). Antecedents, consequences, and challenges of small and medium-sized enterprise digitalization. *Journal of Business Research, 112*, 119–127. https://doi.org/10.1016/j.jbusres.2020.03.004

[5] Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319-340. https://doi.org/10.2307/249008

[6] Grandon, E. E., & Pearson, J. M. (2004). Electronic commerce adoption: An empirical study of small and medium US businesses. *Information & Management, 42*(1), 197-216.

[7] Wang, Y., Su, X., & Guo, S. (2024). Digitalization and firm innovation performance: The mediating role of digital drive and strategic flexibility. *Journal of Product Innovation Management, 41*(5), 1104–1126. https://doi.org/10.1111/jpim.12736

[8] Kallmuenzer, A., Mikhaylov, A., Chelaru, M., & Czakon, W. (2024). Adoption and performance outcome of digitalization in small and medium-sized enterprises. *Review of Managerial Science, 19*, 2011–2038. https://doi.org/10.1007/s11846-024-00744-2

[9] Hassan, M. U., Iqbal, Z., & Khan, M. I. (2018). The role of microfinance in poverty alleviation: A case of Gilgit-Baltistan, Pakistan. *Journal of Mountain Area Research, 3*(1), 25-34.

[10] Kurnia, S., Choudrie, J., Mahbubur, R. M., & Alzougool, B. (2015). E-commerce technology adoption: A Malaysian grocery SME retail sector study. *Journal of Business Research, 68*(9), 1906-1918.

[11] Rahayu, R., & Day, J. (2015). Determinants of e-commerce adoption by SMEs in developing countries: Evidence from Indonesia. *Procedia-Social and Behavioral Sciences, 195*, 142-150. https://doi.org/10.1016/j.sbspro.2015.06.323

[12] Yang, M., Fu, M., & Zhang, Z. (2023). The adoption of digital technologies in supply chains: Drivers, process and impact. *Technological Forecasting and Social Change, 169*, 120732. https://doi.org/10.1016/j.techfore.2021.120732