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Predicting Factors Influencing MSME Subscription Behavior Towards Digital Services Using Machine Learning

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Abstract. *The adoption of digital services among Micro, Small, and Medium Enterprises (MSMEs) has become increasingly important for supporting business operations and digital transformation initiatives. Understanding the factors associated with subscription behavior toward digital services may assist service providers in developing effective customer retention strategies. This study aims to examine the associations among MSME characteristics, digital service utilization, and subscription behavior toward Telkom Indonesia's digital services using a combination of statistical analysis and explainable machine learning. A total of 150 MSME respondents were selected through stratified random sampling. Data were collected through structured online questionnaires and secondary data sources. The analysis included descriptive statistics, Pearson correlation analysis, and Random Forest classification integrated with SHAP (Shapley Additive Explanations) for model interpretability. The results indicate that MSME characteristics and digital service utilization are positively associated with subscription behavior. The Random Forest model achieved an accuracy of 0.91 and an AUC of 0.94, while SHAP analysis identified digital service utilization, service usage duration, and technological readiness as the variables contributing most strongly to model predictions. These findings suggest that behavioral engagement with digital services and organizational readiness are both relevant to understanding subscription continuity among MSMEs. The study contributes to the literature by integrating correlation analysis, machine learning classification, and explainable artificial intelligence to examine subscription behavior within the context of MSME digital services.*

Keywords: *MSMEs; digital service utilization; subscription behavior; random forest; explainable artificial intelligence; shap.*

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Introduction

Digital transformation has increasingly influenced how Micro, Small, and Medium Enterprises (MSMEs) manage business operations, interact with customers, and compete in evolving market environments. The adoption of digital services has been associated with operational efficiency, business resilience, and market expansion. Although digital infrastructure and connectivity in Indonesia continue to improve, with internet penetration reaching approximately 79.5% or about 221.6 million users, evidence indicates that the level of digital service utilization among MSMEs varies across sectors and business categories (APJII, 2025). The importance of digital adoption is further reflected in the growth of Indonesia's digital economy, which reached approximately USD 70 billion in 2021 and has continued to expand in subsequent years (Kementrian Koordinator Bidang Perekonomian Republik Indonesia, 2022). Despite these developments, MSMEs differ considerably in their ability to adopt and utilize digital services due to variations in organizational capacity, technological readiness, managerial capability, and resource availability. Consequently, understanding the factors that influence MSMEs' engagement with digital services remains important for supporting sustainable digital transformation and strengthening business competitiveness.

Telkom Indonesia is one of the digital service providers serving MSMEs within Indonesia's digital business ecosystem. The company offers a range of subscription-based services, including connectivity solutions, cloud computing services, business communication platforms, and digital marketing support, which are designed to support MSMEs in managing business activities and expanding their market reach (Chen, L., K. Ramli, 2023). These services are complemented by integrated digital solutions that support various operational and strategic business functions among MSMEs (KADIN, 2025). Its infrastructure coverage across urban and rural regions provides access to MSMEs with varying business sizes, sectors, and levels of digital readiness. This context provides an opportunity to examine subscription behavior toward digital services across different business sectors, organizational profiles, and levels of digital readiness. Understanding subscription decisions within such a service ecosystem may contribute to the development of more effective customer retention and digital transformation strategies.

This study examines the relationships among MSME characteristics, digital service utilization, and subscription behavior toward Telkom Indonesia's digital services. MSMEs are not a homogeneous group; differences in business size, industry sector, digital readiness, managerial capability, financial resources, and technological capacity may influence how digital services are adopted and utilized (Faiz, Le and Masli, 2024). Digital service utilization, reflected through variables such as frequency of use, diversity of services accessed, duration of use, and operational dependence on digital technologies, may influence subscription continuity and long-term customer engagement (Probohudono et al., 2025). Previous studies suggest that enterprises with higher levels of digital readiness and greater engagement with digital technologies are more likely to integrate digital services into their business processes (Faiz, Le and Masli, 2024; Probohudono et al., 2025). Understanding these relationships is important for identifying factors associated with sustainable digital service adoption among MSMEs. To capture potentially complex interactions among these variables, this study employs a machine learning approach to identify the determinants of subscription behavior toward digital services.

Previous empirical studies have extensively examined MSME digital transformation, digital readiness, and technology adoption (Anatan and Nur, 2023; Pingali et al., 2023; Sagala and Őri, 2024; Díaz-Arancibia et al., 2024). However, several research gaps remain. First, existing studies primarily focus on technology adoption and digital readiness,

while limited attention has been given to subscription behavior and long-term engagement with digital service providers, particularly within integrated digital service ecosystems such as those provided by Telkom Indonesia (Anatan and Nur, 2023). Second, although digital readiness frameworks have been widely developed, their application has rarely been extended to explain subscription continuity, service utilization intensity, service expansion, and switching behavior among MSMEs (Pingali et al., 2023). Third, research on innovative MSMEs has mainly concentrated on initial technology adoption and has provided limited insights into how digital services are continuously utilized and retained to support business development and long-term engagement (Nautwima et al., 2025). Fourth, studies on MSME digital transformation have provided limited evidence regarding behavioral changes associated with subscription patterns and service utilization over time (Sagala and Őri, 2024). From a methodological perspective, although machine learning has been increasingly applied in customer retention and churn prediction studies within the telecommunications industry, existing studies have largely relied on general customer indicators and have seldom integrated MSME characteristics with digital service utilization variables to support managerial decision-making (Chang et al., 2024). Many predictive models emphasize predictive performance, whereas model interpretability receives comparatively less attention (Boozary et al., 2025). Differences in MSME characteristics and digital infrastructure conditions have also received limited attention in explaining digital service utilization and subscription sustainability (Díaz-Arancibia et al., 2024; Probohudono et al., 2025). Addressing these gaps can contribute to a more comprehensive understanding of subscription behavior among MSMEs and support the development of data-driven customer retention strategies.

Based on these research gaps, this study contributes to the literature in two ways. First, it develops a machine learning framework that integrates MSME characteristics and digital service utilization variables to predict subscription behavior toward digital services. Second, it applies Explainable Artificial Intelligence (XAI) through SHAP (Shapley Additive Explanations) to identify and interpret the relative importance of factors associated with subscription behavior. This approach provides empirical evidence regarding the relative importance of factors associated with subscription behavior, which may inform customer retention strategies, service development initiatives, and MSME digital transformation programs. Therefore, this study aims to identify the factors associated with MSME subscription behavior toward Telkom Indonesia's digital services and to generate evidence-based recommendations that support sustainable digital service utilization among MSMEs.

Literature Review

MSME Characteristics and Digital Readiness

The characteristics of MSMEs influence their ability to adapt to the development of digital technologies and integrate digital services into business operations. These characteristics include business size, industry sector, firm age, owner educational background, entrepreneurial experience, and financial capacity. Each characteristic may influence how MSMEs adopt and utilize digital services. Larger enterprises generally possess more structured organizational systems and greater resource availability, enabling them to implement digital technologies more systematically (Faiz, Le and Masli, 2024). In contrast, micro enterprises often encounter constraints related to financial resources, managerial capacity, digital skills, and perceptions of technological risk, which may limit their ability to adopt digital services. The educational background and experience of business owners also influence their understanding of the potential benefits and challenges associated with digital transformation (Pingali et al., 2023).

Previous studies indicate that MSMEs do not exhibit homogeneous digital behavior. Micro enterprises often face greater constraints in financial resources, digital skills, technological infrastructure, and managerial capability than small and medium-sized enterprises, resulting in lower levels of digital adoption and utilization (Pingali et al., 2023; Sagala and Őri, 2024). Medium-sized enterprises generally demonstrate higher technological readiness and greater capacity to integrate digital technologies into operational processes due to more structured organizational resources and managerial capabilities (Faiz, Le and Masli, 2024). These differences suggest that MSME characteristics may influence not only digital service adoption but also the intensity of service utilization and the likelihood of maintaining long-term subscriptions.

Digital readiness reflects the extent to which enterprises possess the resources, capabilities, and organizational support required to implement digital technologies. MSMEs with competent human resources, sufficient financial resources, and supportive leadership are generally better positioned to adopt emerging technologies, including cloud computing services, Internet of Things (IoT)-based systems, and digital marketing platforms (Sagala and Őri, 2024). External factors, including government support, strategic partnerships, and industrial ecosystems that encourage innovation, may further strengthen digital readiness (Affandi et al., 2024). Consequently, MSME characteristics and digital readiness provide an important basis for understanding how enterprises engage with digital services and respond to digital transformation initiatives.

Digital Service Utilization

Digital service utilization refers to the extent to which MSMEs employ digital products, applications, and technology-based platforms to support business activities. These services may include internet connectivity, online communication platforms, cloud computing services, digital accounting systems, and digital marketing tools. The level of utilization may be influenced by perceived usefulness, perceived ease of use, implementation costs, and organizational readiness (Sagala and Őri, 2024). MSMEs that perceive digital technologies as beneficial for improving efficiency and supporting business objectives are more likely to integrate them into routine operations. Conversely, infrastructure limitations, insufficient technical training, and concerns regarding implementation costs may reduce utilization intensity.

The utilization of digital services is also influenced by external conditions such as government policies, financial institution support, collaboration with technology providers, and the broader digital business ecosystem. Empirical evidence suggests that higher frequency and intensity of digital service utilization increase organizational dependence on digital technologies in operational areas such as production, distribution, marketing, and customer service (Affandi et al., 2024). Greater utilization may encourage enterprises to expand the range of digital services used and continue relationships with service providers that are perceived as valuable and reliable. Therefore, digital service utilization may represent an important link between enterprise readiness and subscription-related decisions.

Subscription Behavior

Subscription behavior refers to the decision-making process through which users maintain, renew, expand, reduce, or discontinue the use of digital services. This behavior may be influenced by functional, psychological, and economic considerations that shape perceptions of service value and provider reliability. Customer satisfaction, service quality, perceived usefulness, and subscription costs have been identified as factors associated with subscription continuity and customer retention (Sikri et al., 2024). MSMEs are more likely to maintain service subscriptions when digital services support productivity, operational efficiency, and business performance. Perceived value may therefore influence the willingness of enterprises to continue using digital services over time.

In this study, subscription behavior refers specifically to the decision of MSMEs to maintain, renew, expand, or discontinue the use of Telkom Indonesia's digital services. This construct extends beyond initial technology adoption and reflects the continuity of service utilization over time. Consequently, subscription behavior differs conceptually from technology adoption because an enterprise may adopt digital technologies without maintaining long-term subscriptions to a particular service provider.

Subscription behavior is frequently examined in customer retention and churn analysis because it reflects the sustainability of relationships between users and service providers. Understanding factors associated with subscription continuity may help organizations develop retention strategies, improve service quality, and enhance customer experiences. For digital service providers, identifying variables associated with subscription decisions may support the design of targeted service packages and customer engagement programs (Chang et al., 2024).

Machine Learning and Explainable Artificial Intelligence

Machine learning has been increasingly applied in predictive analytics because of its ability to identify complex patterns and nonlinear relationships within data. Compared with conventional statistical techniques, machine learning models can accommodate interactions among variables without relying on strict distributional assumptions (Sikri et al., 2024). These characteristics make machine learning suitable for analyzing subscription-related decisions that may be influenced by multiple organizational, behavioral, and contextual factors.

Machine learning has also been widely applied in customer retention and churn prediction studies. However, many predictive models primarily emphasize predictive performance, whereas limited attention is given to explaining how individual variables contribute to prediction outcomes. This limitation may reduce the practical usefulness of predictive models for managerial decision-making.

Explainable Artificial Intelligence (XAI) has emerged as an approach for improving model interpretability. Among the available XAI techniques, SHAP (Shapley Additive Explanations) provides a systematic method for quantifying the contribution of individual variables to model predictions (Puthanveettil Madathil et al., 2025). By combining predictive modeling with explainability, SHAP enables researchers to identify factors associated with subscription behavior while maintaining transparency regarding the reasoning behind model **outputs.** This capability may support the translation of analytical results into actionable business insights and evidence-based decision-making.

Conceptual Relationship Among Variables

The literature suggests that MSME characteristics are associated with digital readiness and digital service utilization. Enterprises with stronger human resources, greater financial capacity, and higher levels of technological readiness are generally more capable of integrating digital services into business processes (Faiz, Le and Masli, 2024; Sagala and Őri, 2024). Greater utilization of digital services may increase dependence on digital technologies and influence decisions regarding service continuity and subscription maintenance (Affandi et al., 2024; Sikri et al., 2024).

Based on the literature, MSME characteristics are associated with digital service utilization, while digital service utilization is associated with subscription behavior. These relationships provide the theoretical basis for examining interactions among MSME characteristics, digital service utilization, and subscription behavior. The proposed framework is intended to investigate these associations using an explainable machine learning approach.

Existing studies have primarily focused on technology adoption, digital readiness, or customer retention as separate research domains. Limited evidence is available regarding the integration of MSME characteristics, digital service utilization, and explainable machine learning within a unified framework for understanding subscription behavior. This gap provides the motivation for the present study and supports the application of Random Forest and SHAP to identify factors associated with subscription decisions among MSMEs.

Hypothesis Development

MSME Characteristics and Digital Service Utilization

MSME characteristics reflect internal organizational attributes related to the adoption and utilization of digital technologies in business activities. Previous studies have reported that MSMEs with adequate human resources, stronger managerial competence, and sufficient financial resources generally exhibit higher levels of digital technology utilization (Pingali et al., 2023; Faiz, Le and Masli, 2024). Technological literacy and leadership commitment are also associated with the integration of digital systems into operational processes and business activities (Sagala and Őri, 2024). Previous evidence indicates that MSMEs differ in their levels of digital readiness and technology utilization according to business size, organizational capacity, and resource availability. These differences suggest variation in the extent to which digital services are utilized across MSMEs. Based on the literature, MSME characteristics are associated with digital service utilization.

H1: MSME characteristics are positively associated with digital service utilization.

Digital Service Utilization and Subscription Behavior

Digital service utilization reflects the extent to which MSMEs employ digital technologies and digital platforms to support business activities. The frequency and intensity of utilization indicate the degree to which digital services are incorporated into operational processes. Previous studies have reported that enterprises experiencing greater value from digital services exhibit higher levels of service continuity and customer retention (Affandi et al., 2024; Sikri et al., 2024). The utilization of digital services is therefore related to the continuity of service usage and subscription decisions. Based on these findings, digital service utilization is associated with subscription behavior.

H2: Digital service utilization is positively associated with subscription behavior.

MSME Characteristics and Subscription Behavior

MSME characteristics are also related to subscription behavior. Enterprises with stronger organizational resources, greater financial capacity, and higher levels of technological readiness generally exhibit different patterns of digital service usage and subscription decisions. Previous studies have reported associations between organizational readiness, resource availability, technology utilization, and customer retention decisions (Probohudono et al., 2025; Faiz, Le and Masli, 2024). Variations in MSME characteristics correspond to variations in subscription-related decisions**.** Based on the literature, MSME characteristics are associated with subscription behavior.

H3: MSME characteristics are positively associated with subscription behavior.

Research Methodology

Research Design

This study employs a quantitative approach with descriptive and explanatory objectives. The descriptive component is intended to illustrate MSME characteristics and patterns of digital service utilization, whereas the explanatory component examines the associations among MSME characteristics, digital service utilization, and subscription behavior. The study combines descriptive statistics, correlation analysis, machine learning classification, and model interpretability techniques to provide a comprehensive assessment of factors associated with subscription behavior toward

Telkom Indonesia's digital services. The analytical framework integrates statistical analysis with a machine learning–based predictive approach to support data-driven interpretation and decision-making.

Data Source and Sample

This study utilizes both primary and secondary data obtained from MSMEs that use Telkom Indonesia's digital services. Secondary data were collected from Telkom Indonesia's internal records and official government databases, including data provided by the Central Statistics Agency. Access to Telkom Indonesia's internal records was formally granted for academic research purposes. All records were anonymized prior to analysis to ensure respondent confidentiality and compliance with data protection requirements.

Primary data were collected through structured online questionnaires distributed to active MSME customers across various regions in Indonesia. The study was conducted from January to July 2025 and included enterprises operating in service, trade, and manufacturing sectors located in both urban and rural areas. The geographical distribution of respondents was considered to capture variations in business environments and digital infrastructure conditions that may influence digital service utilization.

The population consisted of MSMEs that currently use or have previously used digital services provided by Telkom Indonesia. A stratified random sampling technique was employed to ensure proportional representation across business size categories and industry sectors. The sample size was determined using the Slovin formula at a 95% confidence level, resulting in 150 MSME respondents. This sample size was considered adequate for statistical analysis and machine learning implementation.

Variable Operationalization

The operational definitions of the variables were established to ensure conceptual clarity and measurement consistency throughout the study.

Each variable was represented through measurable indicators adapted from relevant prior studies.

All questionnaire items were measured using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). MSME characteristics were represented by indicators related to human capital, managerial capability, financial capacity, and technological readiness. Human capital was measured through items reflecting employee digital competence, technology-related skills, and participation in digital training activities. Financial capacity was measured through indicators related to the availability of financial resources for technology adoption and digital investment.

Digital service utilization was measured through indicators related to service usage frequency, diversity of digital services utilized, and the extent to which digital services were integrated into business operations. The digital services examined in this study included connectivity services, digital communication platforms, cloud-based services, and other business-supporting digital solutions provided by Telkom Indonesia.

Subscription behavior referred to the continuity of MSMEs' use of Telkom Indonesia's digital services, including subscription renewal, continued service utilization, service expansion, and service discontinuation.

Data Preprocessing

Prior to analysis, the dataset underwent several preprocessing procedures. Missing values, duplicate observations, and inconsistent records were identified and addressed before model development. Categorical variables were transformed into numerical representations to facilitate machine learning implementation. Data quality assessment was conducted to ensure the reliability of subsequent analyses.

Random Forest Classification

Data analysis was conducted in two stages: (1) descriptive and correlational statistical analysis using Python, and (2) predictive analysis using supervised machine learning techniques. The primary classification algorithm employed in this study was the Random Forest Classifier.

Random Forest was selected because it can accommodate nonlinear relationships, manage interactions among multiple variables, handle mixed data types, and reduce overfitting through ensemble learning mechanisms. These characteristics make Random Forest suitable for modeling subscription behavior, which may be associated with multiple organizational, behavioral, and contextual factors.

The analytical procedure included data preprocessing, feature preparation, model training, validation, and interpretability analysis.

Model Evaluation

Model performance was evaluated using stratified cross-validation to maintain class distribution across validation folds and reduce sampling bias. Classification performance was assessed using Accuracy, Precision, Recall, F1-score , and Area Under the Receiver Operating Characteristic Curve (AUC). These evaluation metrics provide complementary perspectives regarding predictive performance and classification effectiveness.

SHAP-Based Interpretability Analysis

The Random Forest model was integrated with Explainable Artificial Intelligence (XAI) techniques through SHAP (Shapley Additive Explanations). SHAP was applied to quantify the contribution of individual variables to model predictions and improve model interpretability. This analysis enabled the identification of factors associated with subscription behavior and provided insights beyond conventional predictive performance measures. The integration of Random Forest and SHAP facilitated the interpretation of complex relationships among MSME characteristics, digital service utilization, and subscription behavior.

All questionnaire items were measured using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Higher scores indicate greater levels of MSME capability, digital service utilization, and subscription-related commitment. Negatively worded items, such as switching intention, were reverse coded prior to analysis.

Results and Discussion

A total of 150 MSME respondents participated, all of whom were users of Telkom Indonesia's digital services. Data collected covered several dimensions, including business size, sector, ownership profile, education level, and length of operation.

The distribution of data and the diversity of respondents reflect the real-world conditions of MSMEs in Indonesia. The slow pace of capability development among MSMEs is an interesting finding to study and a crucial element in the digital service subscription process. The stagnant competency level of MSME managers poses a significant challenge to the MSME digitalization process. This fact demonstrates the significant gap between the condition of MSMEs in Indonesia and other developed countries.

The Indonesian government has consistently implemented programs to improve MSME management capabilities and involve corporations in upgrading MSME management, but to date, these efforts have not yielded optimal results. This study examines the profile of MSMEs in Indonesia, correlated with their readiness to digitize applications for MSME businesses in Indonesia.

Table 1.
Variable Operational Definitions

Variable	Indicator	Example Measurement Item	Scale	Source
MSME Characteristics (X1)	Human Capital	"Employees in my business possess adequate digital skills to support business operations."	Likert 1–5	Faiz, Le, & Masli (2024); Pingali et al. (2023)
	Managerial Capability	"The business owner is capable of managing digital technologies to support business activities."	Likert 1–5	Faiz, Le, & Masli (2024)
	Financial Capacity	"The business has sufficient financial resources to invest in digital technologies and digital services."	Likert 1–5	Affandi et al. (2024)
	Technological Readiness	"The business possesses adequate technological infrastructure and internet access to support digital operations."	Likert 1–5	Sagala and Őri (2024)
Digital Service Utilization (X2)	Frequency of Use	"Digital services are used regularly to support daily business activities."	Likert 1–5	Affandi et al. (2024)
	Service Diversity	"The business utilizes multiple digital services, such as communication, cloud, marketing, and analytics platforms."	Likert 1–5	Liu et al. (2024)
	Service Integration	"Digital services are integrated into operational and managerial business processes."	Likert 1–5	Probohudono et al. (2025)
Subscription Behavior (Y)	Subscription Continuity	"The business intends to continue subscribing to Telkom Indonesia's digital services."	Likert 1–5	Sikri et al. (2024)
	Service Expansion	"The business is willing to upgrade or expand the use of Telkom Indonesia's digital services."	Likert 1–5	Sikri et al. (2024)
	Switching Intention	"The business is considering switching to another digital service provider." (reverse coded)	Likert 1–5	Liu et al. (2024)
	Perceived Service Value	"The digital services provide value that supports business performance and operational efficiency."	Likert 1–5	Probohudono et al. (2025)

Table 2.
Respondent Characteristics

Characteristic	Category	Age (%)
Business Size	Micro	40.0
	Small	36.7
	Medium	23.3
Business Sector	Services	38.7
	Trade	34.7
	Manufacturing	26.6
Years of Operation	< 3 years	18.0
	3–5 years	30.0
	> 5 years	52.0
Owner's Education Level	High School	32.0
	Bachelor's Degree	50.0
	Postgraduate	18.0
Digital Service Usage Duration	< 1 year	20.0
	1–3 years	48.0
	> 3 years	32.0

Table 2 shows that the majority of respondents belong to MSMEs (76.7%) operating primarily in service and trade sectors (73.4%). Most of these businesses have been operating for more than five years, indicating that they have reached a relatively stable stage of business development. In terms of education, half of the business owners hold a bachelor's degree, which suggests an adequate level of digital literacy to support the adoption of digital technologies. Furthermore, 48% of respondents have used Telkom Indonesia's digital services for one to three years, showing a moderate level of engagement that allows for the analysis of both retention and churn tendencies. These characteristics collectively provide a representative overview of MSMEs actively involved in digital transformation and serve as the empirical foundation for the subsequent analysis of digital service utilization and subscription behavior.

The respondent profile indicates substantial variation in business size, business sector, operational experience, and duration of digital service utilization. This diversity supports the inclusion of MSME characteristics as an important analytical variable and aligns with

previous studies suggesting that MSMEs exhibit heterogeneous levels of digital readiness and technology utilization. The findings also demonstrate that the sample includes micro, small, and medium-sized enterprises operating under different business conditions, thereby providing a broader representation of MSME digital service users.

The descriptive analysis results presented in Table 3 indicate that MSME Characteristics (X1), Digital Service Utilization (X2), and Subscription Behavior (Y) generally exhibit relatively high mean values.

Table3.
The Results Of The Descriptive Analysis

Indicator	Mean	Standard Deviation	Category
Human resource and managerial capacity	4.12	0.65	High
Financial capacity	3.95	0.71	High
Technological readiness	4.05	0.68	High
Frequency of usage	4.21	0.59	High
Diversity of digital services	4.08	0.63	High
Duration of usage	3.88	0.75	Moderate
Subscription continuity	4.16	0.66	High
Satisfaction with services	4.19	0.60	High
Termination potential (churn)	2.14	0.82	Low

The mean value of MSME Characteristics (4.04) suggests that respondents generally report favorable levels of human resource capability, financial capacity, and technological readiness. These findings indicate that participating MSMEs possess organizational resources that support the adoption and utilization of digital technologies.

Digital Service Utilization has a mean value of 4.06, indicating that digital services are frequently used across various business activities. The relatively high values observed for service usage frequency and service diversity suggest that digital technologies have become integrated into operational processes among many respondents. However, the duration of service utilization exhibits a comparatively lower mean value (3.88), indicating differences in the length of digital service experience among MSMEs.

Subscription Behavior demonstrates the highest mean value (4.18), reflecting positive evaluations of service continuity and perceived service value.

The relatively low mean value for churn tendency (2.14) suggests a limited intention among respondents to discontinue digital service subscriptions.

Although the overall mean values indicate relatively high levels of digital service utilization and subscription behavior, variation remains observable across individual indicators. The moderate value associated with service utilization duration suggests differences in digital maturity among MSMEs. This finding is consistent with previous studies reporting that MSMEs differ in their levels of digital readiness, technological capability, and experience with digital transformation.

Table 4.
The Result of Correlation Analysis

Variable	r	p-value	Description
MSME Characteristics (X1)→Subscription Behavior (Y)	0.67	0.000	Positive & significant relationship
Digital Service Utilization (X2) → Subscription Behavior (Y)	0.78	0.000	Positive & significant relationship
MSME Characteristics (X1)→ Digital Service Utilization (X2)	0.72	0.000	Positive & significant relationship

The Pearson correlation analysis was conducted to examine the relationships among MSME Characteristics (X1), Digital Service Utilization (X2), and Subscription Behavior (Y).

The results indicate that all examined relationships are positive and statistically significant at the 0.05 significance level. The correlation coefficient between MSME Characteristics and Subscription Behavior is 0.67, indicating a positive association between organizational characteristics and subscription-related decisions. MSMEs with stronger human resource capability, financial capacity, and technological readiness tend to report higher levels of subscription continuity.

The correlation coefficient between Digital Service Utilization and Subscription Behavior is 0.78, representing the strongest relationship observed in this study. This finding suggests that enterprises that utilize digital services more extensively tend to demonstrate stronger subscription continuity and service retention behavior.

The positive correlation between MSME Characteristics and Digital Service Utilization ($r = 0.72$) indicates that enterprises with stronger organizational resources and technological readiness generally report higher levels of digital service utilization.

Among the examined relationships, Digital Service Utilization exhibits the strongest correlation with Subscription Behavior.

This finding suggests that the extent to which digital services are integrated into business activities may be more closely associated with subscription continuity than organizational characteristics alone. The result is consistent with the argument that continued utilization may strengthen the perceived value of digital services and encourage long-term engagement with service providers.

The Random Forest Classifier was employed to model subscription behavior among MSMEs using organizational, technological, and behavioral variables. The analytical process included data preprocessing, feature preparation, model training, cross-validation, and interpretability analysis through SHAP.

The evaluation results presented in Figure 1 indicate strong predictive performance. The Random Forest model achieved an accuracy of 0.91, precision of 0.90, recall of 0.89, F1-score of 0.89, and AUC of 0.94.

The accuracy value indicates that the model correctly classified approximately 91% of observations. The precision score suggests that most predicted subscription continuations corresponded to actual subscription continuations. The recall value indicates that the model successfully identified a large proportion of actual continuing subscribers. The F1-score reflects a balanced trade-off between precision and recall, while the AUC value indicates strong discrimination between subscription continuation and discontinuation outcomes.

The overall performance metrics suggest that subscription behavior is associated with a combination of organizational, technological, and behavioral factors rather than a single variable. The high AUC value indicates that the Random Forest model effectively distinguishes between different subscription outcomes and supports the suitability of machine learning approaches for modeling customer behavior within digital service environments.

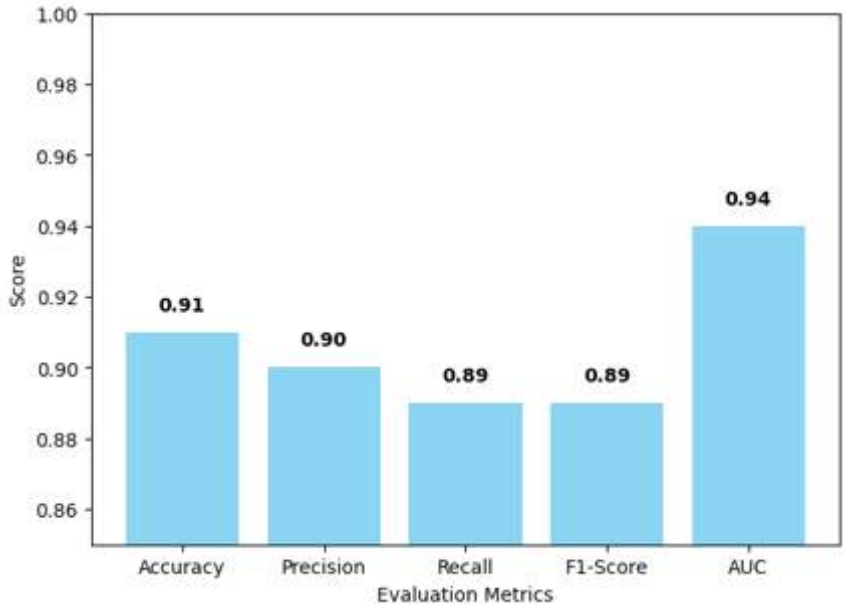

Figure 1.
Model Evaluation Metrics (Random Forest Classifier)

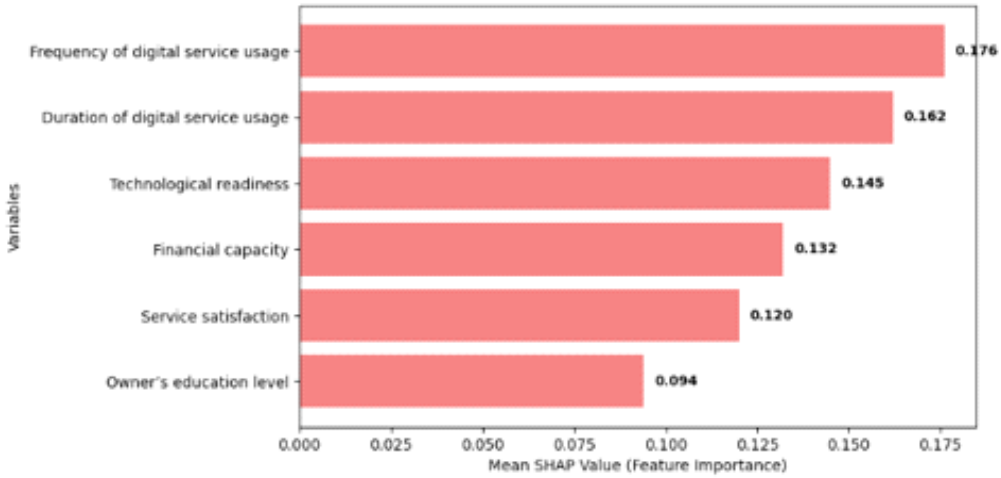

Figure 2.
Mean SHAP Values by Feature Importance

The SHAP analysis was conducted to identify the relative contribution of each variable to the Random Forest model predictions. The results indicate that digital service utilization is the most influential feature in the prediction model, followed by duration of digital service usage and technological readiness. Financial capacity, customer satisfaction, and owner educational level also contribute to the model, although their relative contributions are smaller.

The SHAP analysis provides additional insights beyond predictive performance by identifying variables that contribute most strongly to model predictions. Digital service utilization emerged as the most influential feature, indicating that actual engagement with digital services is more closely associated with subscription behavior than demographic or organizational background characteristics. This finding suggests that continued interaction with digital services may strengthen perceived value and support subscription continuity.

The importance of service utilization duration indicates that long-term experience with digital services is associated with stronger subscription commitment. MSMEs that have utilized digital services for extended periods may have accumulated operational knowledge, developed routine dependence on digital platforms, and integrated these services into business processes.

Technological readiness also appears among the most influential variables, highlighting the importance of organizational preparedness in supporting sustained digital service utilization. MSMEs with higher levels of technological readiness may be better positioned to derive value from digital services and maintain long-term service relationships.

From a managerial perspective, the SHAP findings suggest that customer retention strategies should not focus exclusively on demographic characteristics. Greater emphasis may be placed on increasing service utilization, strengthening technological readiness, and supporting long-term customer engagement through training programs, onboarding initiatives, technical assistance, and service integration strategies. These findings provide practical insights for Telkom Indonesia in designing customer retention and digital service development programs that are aligned with the needs and capabilities of MSMEs.

Discussion

The results indicate that MSME characteristics are positively associated with subscription behavior toward Telkom Indonesia's digital services. The findings suggest that human resource capability, technological readiness, and financial capacity are related to the continuity of digital service utilization among MSMEs. This result is consistent with Pingali et al. (2023), who reported that technological readiness and digital literacy are associated with successful technology adoption among small enterprises. Similar findings were reported by Faiz et al. (2024), who observed associations between managerial competence, financial support, and engagement with digital platforms. However, the present findings differ from those reported by Onitsuka et al. (2018), who suggested that internal MSME characteristics may not always be closely associated with digital adoption, particularly in areas with limited digital infrastructure. One possible explanation for this difference is the research context. The MSMEs included in this study were users of Telkom Indonesia's digital services and operated within an environment where digital infrastructure was relatively accessible, which may strengthen the relationship between organizational readiness and digital service utilization.

The findings also indicate that digital service utilization exhibits the strongest association with subscription behavior. MSMEs reporting higher levels of service usage frequency and longer utilization duration also report stronger subscription continuity. This finding is consistent with Sagala and Őri (2024), who reported that intensive utilization of digital technologies is associated with customer

retention and continued service usage. Affandi et al. (2024) similarly observed that broader utilization of digital services is related to operational efficiency and user satisfaction. These findings suggest that actual engagement with digital services may be more closely associated with subscription continuity than organizational characteristics alone.

Technological readiness and financial capacity also appear among the variables associated with subscription behavior. This finding is consistent with Wang and Zhang (2025), who reported that organizational readiness is associated with the effective integration of digital technologies into operational processes. In the context of MSMEs, technological readiness may facilitate the utilization of digital services, while financial capacity may support investments in digital infrastructure, employee training, and service expansion.

The combined interpretation of correlation analysis, Random Forest classification, and SHAP-based interpretability provides complementary insights into subscription behavior. The correlation analysis indicates positive associations among MSME characteristics, digital service utilization, and subscription behavior. The Random Forest model demonstrates strong predictive performance, while SHAP identifies the variables contributing most strongly to model predictions. The convergence of these findings suggests that subscription behavior is associated with both organizational readiness and actual engagement with digital services. In particular, the prominence of utilization-related variables in the SHAP analysis indicates that behavioral interaction with digital services may be more closely related to subscription continuity than demographic characteristics alone.

Implications

The findings contribute to the literature on MSME digital transformation by examining the relationships among MSME characteristics, digital service utilization, and subscription behavior within a single analytical framework. The integration of correlation analysis, machine learning classification, and explainable artificial intelligence provides an additional perspective for understanding factors associated with subscription-related decisions.

From a practical perspective, the results provide evidence that may assist Telkom Indonesia in developing customer retention strategies. The prominence of digital service utilization, technological readiness, and utilization duration suggests that customer retention initiatives may benefit from emphasizing user engagement, digital capability development, onboarding programs, technical assistance, and service integration support. These findings may also be relevant for policymakers and business development institutions seeking to strengthen MSME digital readiness and long-term digital service adoption.

Limitations

Several limitations should be considered when interpreting the findings of this study. First, the study utilized survey responses and secondary data obtained from Telkom Indonesia, which may limit representation of the broader MSME population. Second, the analysis focused on a Random Forest classification model and did not compare alternative machine learning approaches that may produce different predictive outcomes. Third, the study employed cross-sectional data collected during a single period of observation, which limits the ability to examine changes in subscription behavior over time.

Fourth, although the sample included micro, small, and medium-sized enterprises from multiple sectors, the analysis did not examine differences among these categories separately. Future research may investigate whether subscription behavior varies across business size categories, sectors, or geographical regions. Finally, the findings reflect associations among variables and should not be interpreted as evidence of causal relationships.

Recommendations

Future studies may expand the geographical and sectoral coverage of MSME respondents to improve representativeness and enable comparisons across different business environments. Longitudinal research designs may also provide additional insights into changes in subscription behavior and digital service utilization over time.

Future research may compare multiple machine learning approaches, including Gradient Boosting, Extreme Gradient Boosting, LightGBM, Deep Neural Networks, and hybrid analytical frameworks, to evaluate differences in predictive performance and interpretability. Researchers may also explore additional behavioral variables, such as perceived value, trust, user experience, and customer engagement, to develop a broader understanding of factors associated with digital service subscription decisions.

Conclusion

The findings indicate that MSME characteristics, digital service utilization, and subscription behavior are positively associated within the context of Telkom Indonesia's digital services. Human resource capability, financial capacity, and technological readiness are associated with digital service utilization, while utilization-related variables exhibit strong associations with subscription continuity.

The Random Forest model demonstrates strong predictive performance, and the SHAP analysis indicates that digital service utilization, utilization duration, and technological readiness contribute substantially to model predictions. These findings suggest that behavioral engagement with digital services and organizational readiness are both relevant to understanding subscription behavior among MSMEs.

The study contributes to the literature by integrating correlation analysis, machine learning classification, and explainable artificial intelligence to examine factors associated with subscription behavior. From a practical perspective, the findings provide evidence that may support the development of customer retention initiatives, digital capability enhancement programs, and service improvement strategies for MSMEs.

Declaration

Author Contribution

All authors contributed equally as the main contributors of this paper. All authors read and approved the final paper.

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Competing Interest

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

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