



Design and Evaluation of an Adaptive E-CRM Model for Enhancing MSME Competitiveness in the Digital Era

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Abstract:

This study develops and evaluates an adaptive Electronic Customer Relationship Management (E-CRM) model to enhance the competitiveness of Indonesian Micro, Small, and Medium Enterprises (MSMEs) amid accelerating digital transformation. Drawing on the Technology–Organization–Environment (TOE) framework and employing a Design Science Research (DSR) methodology, the study integrates iterative stages of problem identification, design, implementation, and evaluation. Data were collected from surveys of 120 MSMEs, interviews with 15 business owners, and a three-month pilot implementation involving ten enterprises. The proposed adaptive E-CRM model leverages familiar technologies, including the WhatsApp Business API and modular dashboards, to accommodate varying levels of digital readiness. The results indicate significant improvements in business performance, with customer retention increasing by 23.2%, response time reduced from 4.2 to 1.8 hours, and operational costs decreasing by 25.8%. Usability testing using the System Usability Scale (SUS) produced an average score of 78.5, indicating good system acceptability across different levels of digital literacy. These findings demonstrate that context-aware and cost-effective E-CRM solutions can effectively address key barriers faced by MSMEs, including limited digital skills, financial constraints, and human resource limitations. The study contributes theoretically by extending the Technology–Organization–Environment (TOE) framework through the integration of user adaptability and offers a scalable, cost-efficient implementation model for MSMEs in developing economies.

Keywords: CRM; Design Science Research; Digital Transformation; MSMEs; Technology Adoption

1. Introduction

Global digital transformation has become a key enabler of economic growth and business model innovation. The adoption of digital technologies enhances productivity, creates employment opportunities, and promotes inclusive growth (Bansal, 2024; Lukmanova et al., 2024). In developing economies, digital transformation serves as a catalyst for entrepreneurial ventures, encouraging businesses to adopt innovative practices that strengthen competitiveness (Chatterjee et al., 2023; Moussa & Tarek, 2023). Organizations increasingly leverage digital tools to redesign customer engagement strategies, aligning business models with complex consumer demands and driving long-term profitability (Bodrožić & Adler, 2022). Within this paradigm, Customer Relationship Management (CRM) emerges as a strategic mechanism for gaining competitive advantage by optimizing customer data utilization (Auttri et al., 2023). The evolution toward Electronic Customer Relationship Management (E-CRM) has further amplified this role, integrating digital technologies such as the WhatsApp Business API and Social CRM to enhance customer interaction, personalization, and engagement (Sinulingga & Digdowiseiso, 2024; Jalal et al., 2021). This shift underscores the urgency for organizations, particularly MSMEs, to strategically adopt digital technologies in order to remain competitive in an increasingly digital and customer-centric economy.

The integration of E-CRM has demonstrated its potential to strengthen business performance, particularly among Micro, Small, and Medium Enterprises (MSMEs), which represent approximately 99.92% of all businesses in Indonesia and contribute over 60% to the national GDP (Meilariza et al., 2024; Rumijati & Hakim, 2023). However, despite these promising figures, E-CRM adoption among MSMEs remains limited. Key barriers include low digital literacy, financial constraints, and insufficient human resources, all of which hinder effective implementation (Yuwono et al., 2024; Muthigah et al., 2022). Additionally, uneven Information and Communication Technology (ICT) infrastructure exacerbates these challenges, particularly in developing countries where access to stable internet remains inconsistent. Most existing studies have been conducted in developed contexts, often producing generalized models that fail to address the technological readiness and socio-economic realities of MSMEs in emerging economies (Lecerf & Omrani, 2019). Consequently, there is a critical research gap in developing adaptive, context-aware E-CRM frameworks tailored to the unique needs and capacities of MSMEs in Indonesia. More importantly, existing studies tend to propose generalized E-CRM models that do not adequately account for differences in digital literacy levels and resource constraints among MSMEs. As a result, there is often a mismatch between theoretical models and their practical applicability in real-world MSME environments.

This study aims to design and evaluate an adaptive E-CRM model aligned with the technological readiness levels of Indonesian MSMEs. Unlike prior studies, this research emphasizes adaptability based on varying levels of digital literacy, ensuring that the proposed model can be effectively implemented across MSMEs with diverse technological capabilities. Several theoretical frameworks have been widely used to explain technology adoption, including the Technology Acceptance Model (TAM), Diffusion of Innovation (DOI), and the Technology–Organization–Environment (TOE) framework. While TAM and DOI primarily focus on individual and innovation characteristics, TOE provides a more comprehensive perspective by incorporating organizational and environmental contexts, making it particularly suitable for analyzing technology adoption in MSMEs. Drawing upon the Technology–Organization–Environment (TOE) framework and employing a Design Science Research (DSR) approach, the study integrates iterative processes of problem identification, artifact design, implementation, and evaluation. The proposed model seeks to overcome barriers related to limited digital literacy, human resource capacity, and financial constraints while ensuring that the resulting system remains inclusive, modular, and cost-effective.

Theoretically, this research contributes to the growing body of literature on technology adoption and digital artifact development in developing economies by integrating the TOE framework with DSR methodology. Practically, it offers a scalable and adaptable E-CRM implementation guide for MSMEs, policymakers, and business associations, promoting inclusive and sustainable digital transformation. By bridging the gap between theory and practice, the findings of this study are expected to enhance MSMEs' competitiveness, resilience, and participation in Indonesia's rapidly evolving digital economy. To systematically evaluate the effectiveness and impact of the proposed model, this study formulates the following research questions:

RQ1: How does the implementation of an adaptive E-CRM model affect customer retention among MSMEs?

RQ2: To what extent does the adaptive E-CRM model improve operational efficiency and reduce costs?

RQ3: How does digital literacy level influence the adoption and effectiveness of the E-CRM system?

RQ4: How usable is the adaptive E-CRM model across MSMEs with varying levels of digital readiness?

This study offers two primary contributions. First, it extends the TOE framework by incorporating digital literacy as a critical contextual factor influencing technology adoption in MSMEs. Second, it develops and

empirically validates a cost-effective adaptive E-CRM model that is scalable and accessible for MSMEs with limited technological capabilities.

2. Literature Review

Digital Transformation and Organizational Competitiveness

Digital transformation has become a cornerstone of modern economic development and organizational competitiveness. It enables firms to integrate advanced digital technologies into their strategic operations, thereby improving efficiency, innovation, and customer value creation (Kraus et al., 2022; Egodawele et al., 2022). Scholars argue that digital transformation extends beyond mere technological adoption — it involves a comprehensive reconfiguration of business processes, structures, and capabilities to remain competitive in dynamic markets. In the context of developing economies, digital transformation serves as a catalyst for inclusive growth, allowing firms to overcome structural barriers and reach broader markets (Marolt et al., 2024; Hendrawan et al., 2024). However, despite its recognized benefits, the pace of digital transformation among MSMEs remains uneven due to disparities in digital literacy, resource access, and institutional support (Marolt et al., 2024; Sagala et al., 2024). However, much of the existing literature focuses on large organizations in technologically advanced environments, with limited attention given to the unique constraints faced by MSMEs in developing economies, particularly in terms of digital capability and resource limitations.

The Evolution of Customer Relationship Management (CRM) and E-CRM

Customer Relationship Management (CRM) has evolved from a relational marketing tool into a strategic framework for managing customer data and engagement (Gil-Gómez et al., 2020; Lukman et al., 2023). Early research emphasized CRM's role in enhancing customer loyalty and lifetime value through systematic data collection and personalized marketing (Utami & Sudarmiatin, 2022; Gil-Gómez et al., 2020). The emergence of Electronic CRM (E-CRM) marked a paradigm shift, incorporating internet-based technologies to automate communication, collect behavioural data, and deliver personalized experiences (Lukman et al., 2023; Alghamdi et al., 2023). More recent studies highlight how E-CRM leverages advanced digital tools—such as chatbots, social-media integration, and APIs—to deepen customer relationships and improve retention (Alghamdi et al., 2023; Lukman et al., 2023). Consensus across the literature suggests that E-CRM integration improves marketing efficiency, responsiveness, and customer satisfaction (Utami & Sudarmiatin, 2022; Gil-Gómez et al., 2020). Nevertheless, prior studies largely emphasize technological advancement and system capabilities, with limited consideration of usability and adaptability for small-scale businesses with varying levels of digital literacy.

E-CRM in MSMEs: Opportunities and Barriers

E-CRM adoption offers significant opportunities for MSMEs to enhance competitiveness, market reach, and customer retention (Utami & Sudarmiatin, 2022; Herman et al., 2020). Studies consistently show that E-CRM facilitates better decision-making through customer data analytics and supports agile marketing strategies, particularly for small firms seeking cost-effective solutions (Utami & Sudarmiatin, 2022; Al-Qershi et al., 2020). However, multiple barriers limit its widespread adoption. The most frequently cited include low digital literacy, inadequate funding, and limited managerial capacity (Hendrawan et al., 2024; Sagala et al., 2024). Structural challenges—such as inconsistent ICT infrastructure and dependence on manual processes—further constrain E-CRM implementation in developing economies (Lecerf & Omrani, 2019; Hendrawan et al., 2024). The literature thus indicates a pronounced gap between MSMEs' recognition of E-CRM benefits and their practical ability to operationalize these systems (Religia et al., 2025; Utami & Sudarmiatin, 2022). However, much of the existing evidence is derived from technologically mature settings and larger firms, which limits its transferability to MSMEs in developing economies. These studies often assume stable digital infrastructure, dedicated technical staff, and relatively homogeneous user capability—conditions that are rarely present in Indonesian MSMEs. Consequently, their proposed E-CRM models may be conceptually valid yet operationally difficult to implement in low-resource environments.

Theoretical Foundations: TOE Framework and Design Science Research (DSR)

The Technology–Organization–Environment (TOE) framework, first articulated by Tornatzky and Fleischer (1990), has become a dominant model for analyzing technology adoption within organizations. It conceptualizes adoption

as an outcome of three contextual dimensions: technological readiness, organizational capacity, and environmental influence (Religia et al., 2025; Sagala et al., 2024). Numerous empirical studies validate its robustness in explaining digital innovation adoption across industries (Religia et al., 2025; Moreira et al., 2025). Meanwhile, the Design Science Research (DSR) paradigm emphasizes the creation and evaluation of artifacts that solve real-world problems through iterative design and testing (Gregor & Hevner, 2013; Drechsler & Hevner, 2018). Combining TOE and DSR provides a dual lens: TOE identifies contextual determinants of adoption, while DSR ensures that the developed artifact is both practical and theoretically grounded. Despite their complementary strengths, few studies have applied this integration specifically to E-CRM development for MSMEs in emerging markets, highlighting a clear opportunity for novel contributions (Religia et al., 2025; Moreira et al., 2025). Despite their complementary strengths, the integration of TOE and DSR in developing adaptive E-CRM solutions for MSMEs remains limited, particularly in empirical studies conducted within developing country contexts.

Synthesis and Research Direction

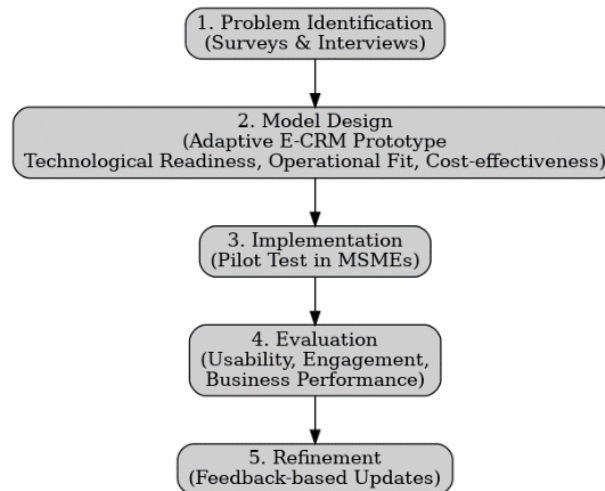
The literature converges on several important insights; however, it also reveals significant theoretical and practical gaps that require further investigation. First, digital transformation and E-CRM integration are essential for sustaining competitiveness in the modern economy (Kraus et al., 2022; Egodawele et al., 2022). Second, MSMEs, despite being central to economic growth, continue to face systemic barriers to E-CRM adoption due to limited resources and infrastructure (Hendrawan et al., 2024; Sagala et al., 2024). Third, methodological innovations—particularly the combination of the TOE framework and DSR approach—remain underutilized in addressing these barriers (Religia et al., 2025; Moreira et al., 2025). Moreover, previous studies rarely integrate these perspectives into a unified framework that simultaneously addresses technological, organizational, and user adaptability challenges in MSMEs. This lack of integrative and adaptive approaches highlights a critical gap in the literature, particularly in addressing the practical implementation challenges faced by MSMEs in resource-constrained environments. Therefore, this study builds upon converging evidence from these streams to propose and evaluate an **adaptive E-CRM model** tailored to the contextual realities of Indonesian MSMEs. This integrative approach seeks not only to advance theoretical understanding of technology adoption but also to produce practical tools that facilitate inclusive digital transformation. Despite the growing body of literature on E-CRM adoption and digital transformation, several critical limitations remain insufficiently addressed in existing studies. First, most existing studies focus on general CRM implementation without addressing the need for adaptive systems that can accommodate varying levels of digital literacy among MSMEs. Second, prior research tends to emphasize technological capability while underestimating the importance of usability and contextual alignment in low-resource environments. Third, empirical validation of E-CRM models in real MSME settings, particularly in developing countries, remains limited.

Therefore, this study addresses these gaps by proposing and evaluating an adaptive E-CRM model specifically designed to align with the technological readiness, digital literacy levels, and operational constraints of MSMEs. By integrating the TOE framework with the Design Science Research approach, this study not only advances theoretical understanding of technology adoption in resource-constrained environments but also delivers a practical and scalable solution validated through real-world implementation. This approach ensures that the proposed model is both contextually relevant and empirically grounded, thereby bridging the gap between theory and practice. In addition, prior studies have rarely examined whether E-CRM effectiveness depends on differences in user readiness and digital literacy. This omission is important because a model that performs well in digitally mature firms may underperform in MSMEs where technological familiarity, staffing capacity, and financial flexibility are limited.

3. Method

This research employs the Design Science Research (DSR) methodology, which is well-suited for the development and assessment of information technology-based solutions to real-world issues (Gregor & Hevner, 2013). This method enables the iterative development of artifacts, such as an adaptive E-CRM model, through the stages of problem identification, design, implementation, evaluation, and refinement (Wieringa, 2014). The primary objective is to develop an E-CRM system that aligns with the technological readiness and operational conditions of MSMEs. Figure 1 illustrates the research procedure.

Figure 1. Research Procedure Flowchart



Source: Author's own elaboration (2025)

The study was conducted in Surakarta, Indonesia, with 120 MSMEs serving as survey respondents and 15 MSME owners serving as semi-structured interview participants. The prototype trial included ten MSMEs from a variety of sectors, including retail, culinary, and services. The study employed a purposive sampling technique, selecting MSMEs based on their sector diversity, operational scale, and varying levels of digital literacy. This approach ensures representation of the heterogeneous characteristics of Indonesian MSMEs while enabling in-depth evaluation of the adaptive E-CRM model. This sampling approach is particularly appropriate for capturing variations in digital maturity and ensuring that the proposed model is evaluated across diverse operational contexts. The participants were selected to reflect the diversity of Indonesian MSMEs, particularly in terms of sector, operational scale, and levels of digital preparedness. (Peffer et al., 2007). A quantitative survey was conducted to identify barriers to E-CRM adoption and levels of technology readiness, and in-depth interviews were conducted to investigate user requirements and expectations. Primary data were obtained from the survey, semi-structured interviews, system usage records, and direct feedback collected during the pilot implementation. All participants were informed about the purpose of the study and provided their consent prior to participation. Confidentiality and anonymity of the respondents were strictly maintained throughout the research process. Customer retention data were specifically derived from transaction histories and repeat purchase records obtained from system-generated data during the pilot implementation. Operational cost data were collected from financial records provided by participating MSMEs. This ensures that the measurements are based on objective and verifiable business performance indicators.

Additional data was gathered from system usage records and direct feedback from MSME owners during the three-month prototype trial. The Indonesian Ministry of Cooperatives and SMEs provided official reports that served as secondary data sources. A Likert-scale questionnaire and interview guides were employed as data collection instruments, while the System Usability Scale was employed to assess usability (Bangor et al., 2009). To ensure the validity and reliability of the instrument, a pilot test was conducted with 20 MSMEs prior to the main data collection. The reliability of the questionnaire was assessed using Cronbach's alpha, with all constructs exceeding the acceptable threshold of 0.70. Content validity was established through expert review involving two academic experts and one industry practitioner. The questionnaire consisted of 25 items measured using a five-point Likert scale, covering key variables such as digital readiness, E-CRM usage, perceived usefulness, and operational efficiency. Five DSR stages were implemented during the artifact development procedure. Initially, barriers to E-CRM adoption were analyzed to identify problems, such as low digital literacy, perceived high costs, and limited human resources. Secondly, the model design stage resulted in an adaptive E-CRM prototype that was integrated with low-cost modules and popular platforms, including the WhatsApp API and social media, and that met three critical criteria: technology readiness, operational suitability, and cost-effectiveness. This design enabled the implementation of various configurations in accordance with the level of digital readiness: a straightforward interface for low readiness, automation features for medium readiness, and analytics modules for high readiness. Third, prototype trials were conducted in 10 designated MSMEs, and system usage training was

provided. Fourth, the evaluation encompassed business impact through indicators of operational efficiency, consumer engagement, and repeat transactions, as well as usability measurements using SUS. Fifth, the evaluation results were used to refine the interface, optimize WhatsApp Business integration, and reduce the complexity of data entry.

A combined methods approach was employed for data analysis. Quantitative data were analyzed using SPSS version 26, while qualitative data were analyzed using thematic analysis supported by manual coding techniques. Descriptive statistics were employed to evaluate changes in customer retention rates and cost efficiency from quantitative data, while thematic analysis was employed to identify user experience patterns from qualitative data obtained from interviews and usage records (Creswell, 2014). This method guarantees that the adaptive E-CRM model that emerges is both scientifically rigorous and practical for MSMEs. To further validate the observed changes in customer retention, a paired sample t-test was applied to compare performance before and after the implementation of the adaptive E-CRM model. This statistical technique is appropriate for analyzing two related samples measured under different conditions. A significance level of 0.05 was used as the threshold for determining statistical significance. The hypotheses were defined as follows:

H0: There is no significant difference in customer retention before and after E-CRM implementation.

H1: There is a significant improvement in customer retention after E-CRM implementation.

4. Findings and Discussion

Findings

The pilot implementation involved ten carefully selected MSMEs representing diverse business sectors and digital readiness levels across Surakarta. These enterprises were chosen to ensure comprehensive representation of the Indonesian MSME landscape, with particular attention to varying technological capabilities and operational scales. The selection criteria prioritized businesses with different levels of digital literacy to validate the adaptive nature of the proposed E-CRM model.

Table 1. Profile of Pilot MSMEs

MSME ID	Business Sector	Business Scale	Digital Literacy Level	Years of Operation	Monthly Revenue Range (IDR)
MSME-01	Culinary (Restaurant)	Medium	High	8	50-100 million
MSME-02	Retail (Fashion)	Small	Medium	5	20-50 million
MSME-03	Services (Laundry)	Small	Low	3	10-30 million
MSME-04	Culinary (Coffee Shop)	Medium	High	6	40-80 million
MSME-05	Retail (Electronics)	Small	Medium	4	25-45 million
MSME-06	Services (Beauty Salon)	Small	Low	2	15-35 million
MSME-07	Culinary (Catering)	Medium	Medium	7	60-120 million
MSME-08	Retail (Handicrafts)	Micro	Low	3	5-20 million
MSME-09	Services (Automotive)	Small	Medium	9	30-60 million
MSME-10	Culinary (Bakery)	Small	High	4	20-40 million

Source: Author's own elaboration (2025)

The respondent profile reveals a balanced distribution across business sectors, with 40% operating in culinary services, 30% in retail, and 30% in various service industries. Regarding digital literacy levels, 30% demonstrated high digital competency, 40% possessed medium-level skills, and 30% exhibited low digital literacy. This distribution effectively represents the heterogeneous nature of Indonesian MSMEs and validates the need for adaptive E-CRM solutions. The implementation of the adaptive E-CRM model yielded significant improvements in both customer relationship management and operational efficiency. Over the three-month evaluation period,

participating MSMEs experienced substantial enhancements in customer retention rates and notable reductions in operational costs through strategic automation of communication processes. Customer retention improvements were consistently observed across all participating enterprises, with the most significant gains recorded among businesses with medium to high digital literacy levels. The automated communication features, particularly WhatsApp-based notifications and personalized customer reminders, contributed substantially to enhanced customer engagement and loyalty. Additionally, the simplified customer database management enabled more effective tracking of customer preferences and purchase histories. This improvement can be explained by the reduction of communication delays and increased personalization enabled by the system. Faster response times and tailored customer interactions enhance perceived service quality, which in turn strengthens customer trust and loyalty.

To further validate the observed improvements in customer retention, an inferential statistical analysis was conducted using a paired sample t-test. The analysis compared retention performance before and after the implementation of the adaptive E-CRM model across the ten participating MSMEs. The results revealed a statistically significant increase in customer retention, with a mean difference of 29 (SD = 2.11), $t(9) = 43.5$, $p < 0.001$. These findings directly address RQ1, confirming that the adaptive E-CRM model significantly improves customer retention among MSMEs. To further assess the magnitude of the observed effect, Cohen's d was calculated and indicated a very large effect size, suggesting that the impact of the adaptive E-CRM model is not only statistically significant but also practically substantial. This indicates that the improvement is not due to random variation but can be confidently attributed to the implementation of the adaptive E-CRM model. In addition to statistical significance, the magnitude of the observed improvement indicates a strong practical effect. The increase of 29 repeat customers represents a substantial enhancement in customer loyalty, which is particularly critical for MSMEs that rely heavily on repeat transactions for revenue stability. This suggests that the adaptive E-CRM model not only produces statistically reliable outcomes but also delivers meaningful business value in real operational settings. Furthermore, the relatively low standard deviation suggests consistent improvements across MSMEs, regardless of their sector or digital literacy level. This consistency reinforces the robustness and adaptability of the proposed model in diverse operational contexts.

This finding supports prior research emphasizing the role of E-CRM in enhancing customer engagement and retention. These findings extend the TOE framework by showing that successful adoption in MSMEs depends not only on technological and organizational conditions, but also on user adaptability and digital literacy. In this context, system flexibility appears to be more consequential than technological sophistication alone. This highlights the importance of aligning technological solutions with user readiness, as suggested by the Technology–Organization–Environment (TOE) framework. Compared to prior studies, which primarily emphasize the role of technological capability in E-CRM adoption, this study provides empirical evidence that adaptability plays a more decisive role in MSME contexts. While previous research often assumes a certain level of digital readiness, the findings of this study demonstrate that systems designed with flexibility and simplicity can significantly enhance adoption and effectiveness, even among low-literacy users. This extends the existing literature by highlighting adaptability as a critical dimension of successful digital transformation.

Table 2. Customer Retention Performance Before and After E-CRM Implementation

Performance Indicator			Before Implementation	After Implementation	Absolute Change	Percentage Change
Average Monthly Repeat Customers			125 customers	154 customers	+29 customers	+23.2%
Customer Response Rate to Promotions			62%	78%	+16 percentage points	+25.8%
Customer Complaints (Monthly Average)			37 cases	21 cases	-16 cases	-43.2%
Average Customer Satisfaction Score			3.4/5.0	4.1/5.0	+0.7 points	+20.6%
Customer Inquiry Response Time			4.2 hours	1.8 hours	-2.4 hours	-57.1%

Source: Author's own elaboration (2025)

Cost efficiency improvements were primarily achieved through the automation of routine communication tasks and the reduction of manual administrative processes. This result addresses RQ2 by indicating that the adaptive E-CRM model improves operational efficiency and reduces costs through process automation. However, these cost-related improvements were examined descriptively and should be interpreted with caution until further inferential testing is conducted. The integration of WhatsApp Business API eliminated the need for traditional SMS-based customer communication, while automated appointment reminders and promotional campaigns reduced staff workload significantly. These efficiency gains translated into measurable cost savings across multiple operational areas. Although the cost efficiency improvements were not subjected to inferential statistical testing, the consistent reduction across all cost categories suggests a strong and systematic impact of the E-CRM implementation. Future research could apply statistical validation to cost-related variables to further strengthen the robustness of these findings.

Table 3: Operational Cost Analysis Before and After E-CRM Implementation

Cost Category	Before Implementation (IDR/month)	After Implementation (IDR/month)	Cost Savings (IDR)	Percentage Reduction
Communication Costs	2,450,000	1,680,000	770,000	-31.4%
Administrative Labor	8,200,000	6,150,000	2,050,000	-25.0%
Marketing & Promotion	3,800,000	2,950,000	850,000	-22.4%
Customer Service Operations	1,900,000	1,350,000	550,000	-28.9%
Total Monthly Savings	16,350,000	12,130,000	4,220,000	-25.8%

Source: Author's own elaboration (2025)

The results demonstrate that the adaptive E-CRM model successfully addresses the key challenges identified in the problem statement. This also indicates that technological solutions that align with existing user behavior are more likely to be successfully adopted, particularly in developing economy contexts. These findings suggest that the effectiveness of the adaptive E-CRM model is not solely driven by automation, but also by its ability to align with existing user behavior and communication practices, particularly through familiar platforms such as WhatsApp. The significant improvement in customer retention rates, coupled with substantial cost reductions, validates the effectiveness of the context-aware design approach. Notably, the model's ability to accommodate varying levels of digital literacy ensured that benefits were realized across all participating MSMEs, regardless of their initial technological readiness. The cost efficiency gains were particularly pronounced in communication and administrative operations, where automation replaced manual processes. The 25.8% overall reduction in operational costs provides MSMEs with additional resources that can be reinvested in business growth and development. These findings align with the research objective of developing an affordable and scalable E-CRM solution specifically tailored to the Indonesian MSME context. The statistical significance reported in this study specifically supports the customer retention findings. In contrast, the cost-related improvements were assessed descriptively and therefore warrant further inferential validation in future studies. In addition, the large magnitude of the mean difference indicates a strong practical impact, suggesting that the implementation of the adaptive E-CRM model delivers not only statistically significant but also economically meaningful benefits for MSMEs.

The usability evaluation revealed exceptionally positive user acceptance of the adaptive E-CRM model across all participating MSMEs. The System Usability Scale (SUS) assessment demonstrated consistently high scores, indicating that the user-centered design approach successfully addressed the digital literacy constraints commonly faced by Indonesian small enterprises. The SUS score of 78.5 indicates that the system falls within the "good" usability range, suggesting high acceptability among users. This finding provides a direct answer to RQ4, confirming that the adaptive E-CRM model is usable across MSMEs with varying levels of digital readiness. This result suggests that familiarity with the platform and simplicity of the interface are key factors driving user acceptance among MSMEs. This is particularly significant in the MSME context, where low digital literacy often limits the adoption of new technologies. The modular interface design and intuitive navigation contributed significantly to user satisfaction, with particular appreciation expressed for features that accommodated varying levels of technological proficiency. User feedback consistently highlighted two primary features as most valuable: WhatsApp-based automation and the simplified dashboard interface. The WhatsApp integration proved particularly effective because it leveraged a communication platform already familiar to Indonesian business owners, eliminating the learning curve typically associated with new digital tools. The simplified dashboard

enabled even users with limited digital literacy to access essential customer management functions without overwhelming complexity.

Table 4: Usability Assessment and Feature Adoption Analysis

Assessment Category	Metric	Score/Result	Interpretation
Overall Usability (SUS Score)	Average Score	78.5/100	Above Average (Good)
	Score Range	65-89	Consistent across literacy levels
Feature Utilization Rate	WhatsApp Automation	95%	Most adopted feature
	Simple Dashboard	92%	High acceptance
	Customer Database	87%	Regular usage
	Analytics Module	68%	Moderate adoption
User Satisfaction	Ease of Learning	4.2/5.0	Easy to learn
	Efficiency Improvement	4.4/5.0	Significant improvement
	Overall Satisfaction	4.1/5.0	High satisfaction
Digital Literacy Impact	Low Literacy Users	72.3 SUS	Acceptable usability
	Medium Literacy Users	78.9 SUS	Good usability
	High Literacy Users	84.2 SUS	Excellent usability

Source: Author's own elaboration (2025)

The results in Table 4 demonstrate that feature adoption varies significantly based on digital literacy levels, with advanced features being less utilized by low-literacy users. This reinforces the importance of adaptive system design. The adoption patterns descriptively suggest a relationship between digital literacy levels and feature utilization, although this relationship was not formally tested through correlation or regression analysis in the present study. This finding highlights digital literacy as a critical moderating factor in technology adoption, which should be explicitly considered in future E-CRM implementations. These findings address RQ3, indicating that digital literacy significantly influences both the adoption process and the effectiveness of the E-CRM system. While basic features like WhatsApp automation and simple dashboards achieved near-universal adoption, advanced analytics modules showed lower utilization rates, particularly among users with limited digital experience. This finding validates the adaptive design approach, demonstrating that the system successfully provides value at multiple complexity levels.

The Design Science Research methodology facilitated systematic development and refinement of the adaptive E-CRM model through five distinct phases. Each iteration incorporated user feedback and performance evaluation data, resulting in progressive improvements to both functionality and usability. The iterative approach proved essential for addressing the diverse needs and constraints of Indonesian MSMEs, enabling the development of a truly context-aware solution. The most significant refinements occurred during the evaluation and refinement phases, where user feedback revealed critical areas for improvement. Interface simplification emerged as a primary concern, leading to substantial modifications in dashboard design and navigation structure. Additionally, the integration with WhatsApp Business required multiple iterations to achieve optimal functionality while maintaining cost-effectiveness.

Table 5: Design Science Research Iteration Summary

DSR Phase	Key Activities	Major Findings	Refinements Made	Outcome
Problem Identification	Survey (n=120), Interviews (n=15)	Limited digital literacy (70%), High perceived costs (85%), Lack of HR (78%)	Research scope definition, Target user profiling	Clear problem statement
Model Design	Prototype development, Architecture design	Need for modular approach, WhatsApp integration critical	Simplified interface design, Cost-effective modules	Initial prototype
Implementation	Pilot testing (10 MSMEs), User training	Interface complexity issues, Integration challenges	Dashboard simplification, WhatsApp API optimization	Functional prototype
Evaluation	SUS testing, Performance measurement	High usability (78.5 SUS), Positive business impact	Minor UI adjustments, Feature prioritization	Validated solution

Refinement	User integration, optimization	feedback Final	Request for automation, entry	enhanced Reduced data	Advanced features, workflows	WhatsApp Streamlined	Final adaptive model
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Source: Author's own elaboration (2025)

These iterative improvements demonstrate that continuous user feedback is essential for developing effective digital solutions in MSME contexts, where user needs are highly dynamic. The iterative development process revealed that successful E-CRM adoption among Indonesian MSMEs requires careful balance between functionality and simplicity. Early iterations focused primarily on feature completeness, while later refinements emphasized user experience and operational efficiency. The final model represents a synthesis of technical capability and practical usability, specifically tailored to the Indonesian MSME context. The DSR approach proved particularly valuable for addressing the heterogeneous nature of the target user base. The systematic evaluation and refinement process enabled the development team to identify and resolve usability issues that might have been overlooked in traditional software development approaches. The resulting adaptive E-CRM model demonstrates how rigorous design science methodology can produce contextually appropriate digital solutions for resource-constrained environments.

Overall, these findings provide a comprehensive answer to all research questions. The results confirm that the adaptive E-CRM model improves customer retention (RQ1), enhances operational efficiency and reduces costs (RQ2), is significantly influenced by digital literacy levels (RQ3), and demonstrates high usability across MSMEs with varying technological readiness (RQ4). However, it is important to acknowledge that external factors such as market dynamics, seasonal demand variations, and differences in business types may have influenced the observed results. Additionally, the relatively small sample size of pilot MSMEs may limit the generalizability of the findings. Future studies are recommended to involve larger samples and longer implementation periods to further validate these results.

Discussion

The Technology Organization Environment (TOE) framework is strongly aligned with the implementation of this adaptive E-CRM model. The integration of the WhatsApp API, which is already well-known to MSMEs, has been effective in reducing barriers to the adoption of new technologies and facilitating consumer communication from a technological perspective. WhatsApp-based automation features have the highest utilization rate, at 95%, according to research. These features directly contribute to an increase in customer retention by 23.2% and an acceleration of response times from 4.2 hours to 1.8 hours. Implementation is facilitated by minimal human resource requirements and a brief training process from an organizational standpoint, as evidenced by the consistent average System Usability Scale score of 78.5 across all digital literacy levels, including 72.3 for low-literacy users. In Indonesia, the acceleration of digital transformation of MSMEs is facilitated by environmental factors, which are a combination of competitive pressures and government policy support. This is consistent with the literature, which underscores the significance of external support and customer demand in driving technology adoption (Shahadat et al., 2023; Badghish & Soomro, 2024).

The results of this study also bolster the evidence that supports the significance of digital technology adoption in enhancing the performance and sustainability of MSMEs in developing countries. The data indicate that businesses can reallocate resources to business development by achieving an average operational cost reduction of 25.8%, particularly in the communication and administration categories. This discovery is in accordance with prior research that has demonstrated the advantageous effects of digital technology and e-commerce on business performance and resilience (Yacob et al., 2021). It also validates critical adoption factors, including competitive pressure, relative advantage, and support from top management (Triandini et al., 2023; Shahadat et al., 2023). This research confirms the efficacy of the TOE framework as a guide for technology adoption across diverse environments by developing an adaptive model that addresses the varying levels of technological readiness and operational conditions of Indonesian MSMEs (Telukdarie et al., 2024). Additionally, the study enriches the literature by providing evidence from a developing-country context. In addition, the research results underscore the critical role of the iterative Design Science Research (DSR) process in guaranteeing that the E-CRM model actually aligns with field requirements. Each phase of the development process—from problem identification to refinement—provided valuable feedback, including initial findings regarding interface complexity. These findings were subsequently resolved by optimizing WhatsApp Business integration and simplifying the dashboard. This method not only enhanced the efficacy of the system but also facilitated operational efficiency, as evidenced by a reduction in administrative costs of up to 25% and a reduction

in communication costs of up to 31.4% during the three-month trial. The literature has verified that a systematic DSR process can generate technology artifacts that are more contextual and reliable for MSMEs in developing countries (Gregor & Hevner, 2013). This study illustrates the potential of this dual approach to develop digital solutions that are not only technically effective but also socio-economically pertinent for Indonesian MSMEs by integrating the methodological rigor of DSR and the TOE framework (Susanti et al., 2023).

The results of this study have significant practical implications for the development of digitalization policies and strategies for MSME in Indonesia. In accordance with literature recommendations that underscore the significance of government support and competitive pressure in expediting technology adoption (Shahadat et al., 2023; Qalati et al., 2022), the cost-effective and user-friendly adaptive E-CRM model can function as an implementation guide for small businesses to enhance operational efficiency and customer retention without necessitating substantial investment. This model can serve as a reference for digital training or incentive programs for local governments and MSME associations, as prior research has demonstrated that institutional support and public policy are essential for the success of digital transformation in the micro and small business sector (Alraja et al., 2022; Telukdarie et al., 2024). This study is restricted to the Surakarta region and specific business sectors, despite the positive impact on customer retention and cost reductions that the results indicate. Consequently, additional cross-industry and long-term research is required to evaluate the generalizability and sustainability of this model in the context of other MSMEs in Indonesia and developing countries (Yacob et al., 2021; Affandi et al., 2024). Although the findings are broadly positive, several considerations limit the strength of causal interpretation. The three-month pilot period may have been influenced by seasonal demand patterns, short-term promotional effects, and sector-specific business cycles. In addition, while the descriptive results suggest that digital literacy shapes feature adoption and usability, these relationships were not formally modeled statistically. Therefore, the present findings should be interpreted as strong practical evidence with partial inferential support rather than as a fully comprehensive causal explanation.

5. Conclusion and Recommendation

This study confirms that an adaptive E-CRM model can be effectively developed and implemented to improve MSME performance by aligning system functionality with varying levels of digital readiness. Addressing the research question, the findings demonstrate that an adaptive E-CRM model can be effectively developed through a modular, user-centered, and context-aware approach that aligns system functionality with varying levels of digital literacy. The findings demonstrate significant improvements in customer retention, service quality, and operational efficiency, indicating that the adaptive E-CRM model delivers both operational and strategic value for MSMEs. From a theoretical perspective, this study extends the Technology–Organization–Environment (TOE) framework by emphasizing the role of digital readiness and system adaptability as key determinants of successful technology adoption in MSMEs. The findings highlight that adaptability and user readiness are critical factors in technology adoption, particularly in developing country contexts. A key insight from this study is that system adaptability, rather than technological sophistication alone, plays a decisive role in ensuring successful adoption among MSMEs.

From a practical standpoint, the proposed model provides actionable guidance for MSME owners, policymakers, and business associations in designing inclusive, scalable, and cost-effective digital solutions. These findings suggest that MSMEs do not require complex or high-cost systems, but rather adaptive and user-friendly solutions that align with their operational realities. The model demonstrates how context-aware system design can support broader digital transformation initiatives. However, this study is limited by the relatively small pilot sample, the short three-month evaluation period, and the specific regional context of Surakarta. These limitations restrict the generalizability of the findings and prevent stronger conclusions about long-term causal effects. Future studies should therefore examine whether adaptive E-CRM systems remain effective over longer implementation periods, whether digital literacy continues to moderate feature adoption over time, and how AI-based analytics may alter the cost–benefit balance for MSMEs with limited technical capability. Overall, the findings suggest that adaptive and context-aware E-CRM solutions are strategically important for strengthening MSME competitiveness in increasingly digital markets.

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