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A Hybrid TAM-Fuzzy MCDM Framework for Digital Wallet Adoption: Evidence from GoPay Users

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Abstract
Digital wallets have become a key component of modern financial systems amid the shift toward cashless societies. Understanding adoption requires the consideration of both user perceptions and technological factors, particularly cybersecurity concerns. This study investigates the factors affecting digital wallet adoption by integrating the Technology Acceptance Model (TAM) with the Fuzzy Analytical Hierarchy Process (Fuzzy AHP) to evaluate user behavior and prioritize critical system features. A cross-sectional survey was conducted involving 130 active GoPay users selected through purposive sampling. Multiple linear regression analysis was applied to examine the effects of perceived usefulness and perceived risk on adoption intention, while Fuzzy AHP was utilized to identify the most important evaluation criteria. The findings indicate that perceived usefulness has a significantly positive impact on adoption intention, whereas perceived risk represents a significant barrier to digital wallet acceptance. Together, these factors explain more than 26% of the variance in user adoption behavior. Additionally, the prioritization results reveal that data security and transaction efficiency are considered the most important factors surpassing promotional incentives. This study contributes to digital finance research by linking behavioral acceptance theory with systematic decision-making analysis. These findings highlight the importance of strengthening cybersecurity and operational efficiency to promote sustainable digital wallet adoption.

Keywords: digital wallet adoption; fintech security; fuzzy decision-making; hybrid tam-mcdm; user preferences

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INTRODUCTION

In recent years, the study of digital wallet adoption has undergone a notable transformation, shifting the focus from merely understanding basic functional acceptance to exploring the intricate balance between utility and security in high-risk settings (Hindardjo et al., 2025; Salma & Permatasari, 2025). Indonesia serves as a particularly pertinent case for examining digital financial behavior, given its swift transition towards a cashless society. GoPay has emerged as an exemplary subject for academic scrutiny in this context. The choice of GoPay is supported by its leading market share and its extensive integration into a multifaceted digital ecosystem, encompassing services such as ride-hailing, food delivery, and

everyday transactions. This creates a competitive and complex environment in which user trust and perceived utility are continually challenged by cybersecurity risks (Prawira et al., 2024).

The current body of research on digital wallet adoption can be divided into several key themes. Initially, studies consistently pointed out that psychological factors such as perceived usefulness, trust, and ease of use are the main drivers of adoption among younger users (Ahmed et al., 2024; Husni et al., 2023). However, in well-established fintech environments, recent findings suggest that perceived cyber risk significantly hinders behavioral intention and platform loyalty (Changchit et al., 2025; Hassan et al., 2025; Zhao & Khaliq, 2024). Second, despite these insights, traditional behavioral acceptance models have notable shortcomings. Models such as the Technology Acceptance Model (TAM) effectively capture broad psychological motivations but often fail to explain the complex nature of human judgment when users weigh specific security or functional aspects (Almoghayer & Mahmoud, 2025; Truc, 2024). Third, to tackle evaluation ambiguity, researchers have increasingly turned to Multi-Criteria Decision Making (MCDM) methods, such as fuzzy logic, within fintech settings (Van Nguyen, 2023). These techniques convert subjective linguistic evaluations into clear operational priorities under uncertain conditions (Lubis & Sriani, 2025; Muhidin et al., 2025; Utami et al., 2025). Lastly, a significant research challenge remains due to fragmented literature: behavioral models often lack precise feature prioritization, while MCDM approaches frequently miss the structured psychological basis of consumer behavior (Czechowska & Paduszyńska, 2025; Thalmeiner et al., 2025).

This disconnect reveals a crucial gap in scientific understanding. Depending solely on a behavioral acceptance model does not adequately clarify how users prioritize system features. While the Technology Acceptance Model (TAM) indicates that factors such as utility or risk can influence adoption, it does not specify how these psychological conditions translate into precise architectural requirements. This limitation hinders the progress of technology adoption theory, as it leaves user behavior explanations vague and difficult to apply in system engineering. Therefore, a theoretical foundation must establish a conceptual link before system evaluation: TAM should be used to explain behavioral mechanisms at a macro-psychological level, while the Fuzzy Analytical Hierarchy Process (F-AHP) is necessary to capture the attribute evaluation process at a micro-decision-making level (Belmonte et al., 2022).

Although existing research frequently separates behavioral modeling from functional prioritization, this study introduces an innovative analytical model that structurally connects psychological factors with prioritization of system attributes. By addressing this theoretical gap, this research offers a more thorough understanding of the behavior surrounding digital wallet adoption. The study's scientific contributions include enhancing the Model's explanatory capacity by integrating decision-optimization features, resulting in a detailed two-tier evaluation framework for digital payment systems.

This study introduces a comprehensive hybrid methodological framework that can be applied to a range of financial technology services. While earlier research has delved into behavioral acceptance using extended TAM models in areas such as e-wallets (Persadha et al., 2024) and peer-to-peer lending (Putri et al., 2023), these studies often rely on standalone behavioral models to assess factors such as perceived risk (Hutapea & Wijaya, 2021; Jariyapan et al., 2022) or privacy concerns (Zhang, 2024), which can introduce subjectivity bias. In contrast, this integrated approach employs mathematical quantification of user preferences to achieve more objective assessments. The main aim of this research is to present a validated, conceptual two-tier framework that not only examines the effects of perceived usefulness and perceived risk on behavioral intention, but also identifies the exact priority of functional and security features considered by GoPay users in their adoption decisions.

METHOD

This research utilized a cross-sectional approach that combined the TAM with the Fuzzy Analytical Hierarchy Process (F-AHP). TAM was used to explore the connections between perceived usefulness, perceived risk, and the intention to adopt, whereas F-AHP was employed to rank system attributes according to user preferences, offering an additional evaluation framework. Using purposive sampling, data collection took place online from March to May 2026, targeting active GoPay users in Yogyakarta who had made at least three transactions in the previous month. A total of 130 valid responses were obtained. The sample size surpassed Green's empirical guideline, which suggests a minimum of 66 participants for a regression model with two predictors to ensure sufficient statistical power. Details of the respondents' characteristics can be found in Table 1.

Table 1. Characteristics of gopay users

Characteristic	Category	Frequency (People)	Percentage (%)
Residence	Yogyakarta	91	70%
	Outer Yogyakarta	39	30%
Age	< 20 Years Old	18	13.80%
	20-30 Years Old	107	82.30%
	31-40 Years Old	5	3.80%
Occupation	Students	51	39.20%
	Private-Sector Employees	33	25.40%
	Self-Employed	11	8.50%
	Civil Servants/State-Owned Enterprise Employees	4	3.10%
	Other	31	23.80%

Table 2. Variable structure and rules

Code	Variable	Statement
PU1	Perceived Usefulness	Transaction efficiency
PU2	Perceived Usefulness	Convenient payment options
PU3	Perceived Usefulness	Daily Benefits
PU4	Perceived Usefulness	Finished faster
PR1	Perceived Risk	Concerns about data security
PR2	Perceived Risk	Risk of fraud
PR3	Perceived Risk	Error/Fault System
PR4	Perceived Risk	Loss of access to funds
BI1	Behavioral Intention	Primary payment methods
BI2	Behavioral Intention	Recommendations to others
BI3	Behavioral Intention	Regular use
C1	Fuzzy MCDM Criteria	Data Security & Account Information
C2	Fuzzy MCDM Criteria	Loss Risk Protection
C3	Fuzzy MCDM Criteria	Transaction Efficiency & Speed
C4	Fuzzy MCDM Criteria	Ease of Use of the Application
C5	Fuzzy MCDM Criteria	Promotions & Discounts

The survey tool was modified based on the key TAM literature. To ensure content validity, three experts in information systems conducted a formal review of the initial draft, resulting in an impressive Content Validity Index (CVI) of 0.92. Following this, a pilot test with 30 participants helped clarify minor wording ambiguities. The final quantitative tool employed a typical 5-point Likert scale to measure PU (4 items), PR (4 items), and BI (3 items). Five functional criteria (C1–C5) were assessed (Table 2).

The data analysis process commenced with a thorough verification of the instrument's feasibility. To ensure validity, the Pearson correlation value needed to be less than 0.05. Internal consistency was strictly maintained with a Cronbach Alpha exceeding 0.70. Behavioral drivers were examined using multiple linear regression. Classical assumptions were meticulously checked, including ensuring that the Variance Inflation Factor remained below 10 to effectively avoid multicollinearity. All inferential statistical tests adhered to a stringent significance level of 0.05. Ultimately, F-AHP was employed to rank system features, involving several steps: (1) creating a pairwise matrix based on linguistic evaluations; (2) transforming terms into Triangular Fuzzy Numbers (TFN), as shown in Table 3; (3) calculating fuzzy geometric means; (4) determining synthetic extent; (5) performing defuzzification using the Center of Area (CoA); and (6) normalizing weights. Logical consistency was ensured with a Consistency Ratio (CR) below 0.10.

Table 3. F-AHP linguistic scale and tfn

Linguistic Variable	Triangular Fuzzy Number (TFN)	Reciprocal TFN
Equally Important	(1, 1, 1)	(1, 1, 1)
Moderately Important	(2, 3, 4)	(1/4, 1/3, 1/2)
Strongly Important	(4, 5, 6)	(1/6, 1/5, 1/4)
Very Strongly Important	(6, 7, 8)	(1/8, 1/7, 1/6)
Extremely Important	(9, 9, 9)	(1/9, 1/9, 1/9)

RESULTS AND DISCUSSION

Results

This study presents four key empirical insights into the behavioral patterns associated with digital wallet adoption. Initially, multiple linear regression analysis indicated that psychological factors play a crucial role in predicting users' intentions to adopt. Next, Perceived Usefulness is identified as the primary factor influencing adoption, whereas Perceived Risk consistently serves as a structural obstacle. Additionally, the F-AHP analysis highlights a significant change in user preferences, with a strong emphasis on data security and transaction efficiency over promotional offers. Finally, the integration of methodologies shows that psychological utility and risk directly influence specific operational system requirements.

Prior to structural testing, the data successfully met all construct validity thresholds (Pearson correlation $p<0.05$) and internal reliability standards (Cronbach's Alpha ≥ 0.85 for predictors). Furthermore, the data satisfied the classical regression assumptions, including the absence of multicollinearity (VIF = 1.214). As shown in Figure 1, the multiple linear regression model indicates that Perceived Usefulness and Perceived Risk simultaneously explain 26.4% of the variance in GoPay adoption intention ($R^2 = 0.264$, $p < 0.001$). Within behavioral sciences and technology adoption literature, an R^2 value between 0.20 and 0.30 is generally considered moderate and highly acceptable. In the context of fintech consumer behavior, this value suggests that while the core TAM constructs capture the essential psychological motives for adoption, user decisions in digital ecosystems are multifaceted and influenced by broader situational contexts outside the model.

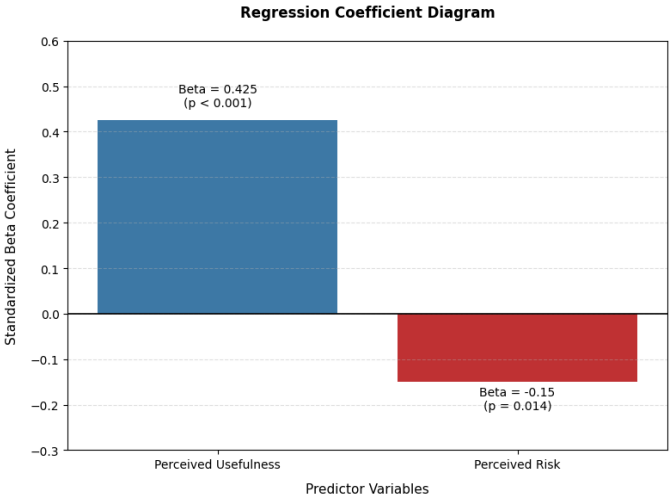

Figure 1. Regression coefficient and effect size diagram

Rather than merely reporting statistical outputs, analyzing the substantive impact of each variable provides deeper insights. As detailed in Table 4, Perceived Usefulness acts as the primary determinant of adoption. Its substantial effect size ($f^2 = 0.211$) hold significant practical implications for fintech strategy, indicating that functional utility is the fundamental engine driving platform usage. Conversely, Perceived Risk remains a significant behavioral barrier. Although its effect size is comparatively smaller ($f^2 = 0.084$), the entirely negative confidence interval indicates that perceived risk has severe consequences for user decisions, and any perceived vulnerability acts as a rigid bottleneck that suppresses adoption regardless of the platform's utility.

Table 4. Summary reliability test results (cronbach's alpha)

Predictor Variable	Standardized Beta	95% Confidence Interval	p-Value	Effect Size (f2)	Conclusion
Perceived Usefulness	0.425	0.264 to 0.549	< 0.001	0.211	Strong Positive Driver
Perceived Risk	-0.150	-0.212 to -0.025	0.014	0.084	Significant Barrier

After assessing the macro-level behaviors, the F-AHP algorithm turned its focus to the micro-level characteristics of the system. The pairwise comparisons resulted in a decision matrix with perfect consistency (Consistency Ratio = 0.000). Table 5 lists the ultimate operational weights. Notably, the empirical data highlight an extremely small difference (under 0.3%) among the top four criteria. This statistical proximity suggests that users do not consider these attributes separately. Instead, contemporary users regard Data Security, Transaction Efficiency, Loss Protection, and Ease of Use as a cohesive "value proposition." They see security and efficiency as fundamental, inseparable infrastructure elements rather than individual features. As a result, Promotional Incentives are relegated to the lowest priority, reflecting a shift in user preferences, where structural dependability takes precedence over short-term financial benefits.

Table 5. Final fuzzy-ahp weighting results

Rank	Criterion	Weight(%)
1	C1 (Data Security)	20.62%
2	C3 (Efficiency)	20.54%
3	C2 (Loss Protection)	20.42%
4	C4 (Ease of Use)	20.38%
5	C5 (Promotions)	18.03%

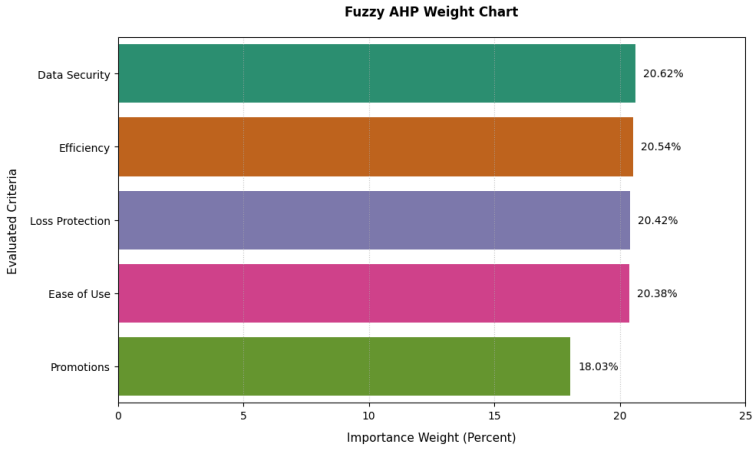

Figure 2. Fuzzy ahp weight chart diagram

As depicted in Figure 2, the category of Data Security & Account Information (C1) was assigned the highest priority weight at 20.62%. This was closely followed by Transaction Efficiency & Speed (C3) with a weight of 20.54%, Loss Risk Protection (C2) at 20.42%, and Ease of Use (C4) at 20.38%. In contrast, Promotions & Discounts (C5) received the lowest weight, at 18.03%. These results suggest that when assessing GoPay services, users tend to value security, transaction efficiency, and risk protection more than promotional offers.

The main methodological advancement of this framework lies in creating a measurable link between psychological causality and multi-criteria decision optimization. Figure 3 shows the combined relationship between the macro-psychological and micro-functional aspects of GoPay adoption. On a macro scale, Perceived Usefulness positively influenced Behavioral Intention ($\beta = 0.425$), while Perceived Risk negatively impacted it ($\beta = -0.150$). These psychological insights are converted into distinct functional priorities at the micro level, where users prioritize transaction efficiency and speed (20.54%), data security (20.62%), and loss-risk protection (20.42%), with ease of use closely following (20.38%). Promotions were given the least priority (18.03%). In summary, the figure indicates that the intention to adopt is influenced not only by perceived usefulness and risk, but also by users' specific expectations concerning security, efficiency, and protection.

The amalgamation of these findings confirms that psychological conditions are intricately converted into operational priorities. The significant behavioral impetus driven by the Perceived Usefulness construct within the regression model is accurately mirrored by the substantial operational weights given to Transaction Efficiency (C3) and Ease of Use (C4) in the F-AHP matrix. Concurrently, the psychological obstacle known as Perceived Risk is empirically manifested and addressed through users' firm prioritization of Data Security (C1) and Loss Risk Protection (C2). This integration illustrates that user behavior in digital wallets is concrete; risk aversion and utility expectations explicitly shape the architectural requirements.

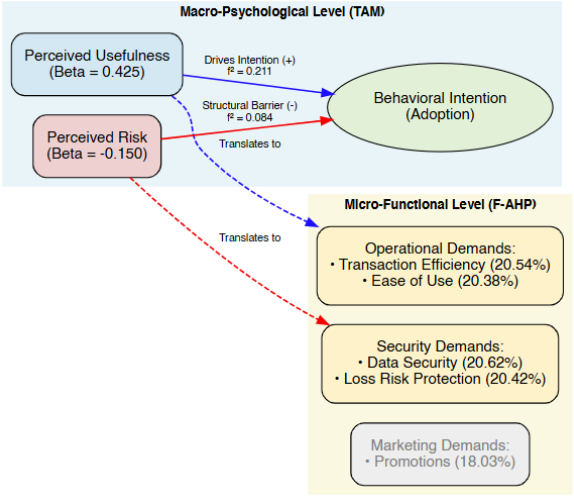

Figure 3. TAM–F-AHP conceptual integration

Discussion

The empirical analysis of this study uncovers several key insights into the mechanisms that drive digital wallet adoption. First, perceived usefulness emerged as the strongest predictor of the intention to adopt. In contrast, perceived risk remains a notable structural obstacle, albeit with a smaller relative impact. In addition, the multi-criteria assessment highlights a significant shift in user priorities, where data security and transaction efficiency significantly surpass promotional incentives. Ultimately, the integration of these models demonstrates that abstract psychological motivations directly influence specific operational system requirements.

In mature digital ecosystems, functional utility serves as an essential foundation for initiating adoption intention, whereas perceived risk acts as a structural barrier that influences the final decision. This dynamic interplay is empirically clarified by the F-AHP results, which show nearly equal weights for data security, transaction efficiency, loss protection, and ease of use, indicating that they form a cohesive value package. This signifies a significant evolution in fintech behavior, as users shift from opportunistic early adopters to rational, risk-averse consumers who prioritize infrastructural reliability.

These findings differ significantly from earlier research, which often highlighted financial promotions and discounts as the main drivers for adopting digital wallets (Ahmed et al., 2024; Husni et al., 2023). This variation is linked to the growing sophistication of the Indonesian fintech sector and is consistent with recent data from high-risk cyber settings (Changchit et al., 2025; Hassan et al., 2025). Moreover, GoPay's features, particularly its extensive integration into everyday socioeconomic activities, necessitate greater system dependability, thereby reshaping user priorities. The respondents' demographic profile, mainly young and digitally savvy individuals, also heightened their awareness of cyber risk. Furthermore, employing a hybrid methodological approach effectively reveals hidden operational priorities that traditional standalone behavioral models often overlook.

This research enhances the explanatory power of the Technology Acceptance Model by providing a comprehensive analytical viewpoint that incorporates novel conceptual connections, rather than asserting complete originality. This reveals that psychological states of adoption are closely tied to particular architectural requirements. As a result, the integration of F-AHP sets new boundary conditions for TAM, indicating that usefulness influences adoption only when fundamental security expectations are satisfied. This thorough model is easily applicable to other technology research areas that demand high levels of trust and system dependability.

In terms of methodology, the research enhances decision support by connecting two separate analytical tiers. The TAM is employed to pinpoint the broad psychological factors influencing adoption, whereas the F-AHP converts these broad factors into precise engineering priorities. By combining these outcomes, a clear and measurable link is formed between behavioral acceptance and system design. This methodological advancement guarantees that empirical findings on behavior can be directly applied to technology development.

The ramifications of these findings are significant across various fields, contributing to Information Systems Research, Human-Computer Interaction, FinTech Adoption Research, Decision Support Systems, and Multi-Criteria Decision-Making Research. From a practical standpoint, evidence requires service providers to realign their strategic investments, moving away from unsustainable marketing tactics. Instead, developers should prioritize strengthening transparent data encryption and improving transaction infrastructure to secure long-term platform loyalty. Temporary incentives are insufficient for maintaining user retention if the fundamental security is seen as compromised (Almoghayer & Mahmoud, 2025; Persadha et al., 2024)

The results must be considered with an awareness of several methodological constraints. First, the cross-sectional nature and dependence on self-reported information might lead to common method bias and hinder the ability to draw strong causal conclusions. Second, the purposive sampling of GoPay users in Yogyakarta restricts the applicability of the results to other populations and geographical areas. Third, while multiple linear regression effectively identifies the main predictors of adoption intention, it fails to capture the intricate relationships among latent constructs that could be explored using Structural Equation Modeling (SEM). Future research could overcome these limitations by employing longitudinal or experimental designs, wider sampling methods, and SEM-based techniques to gain a more thorough understanding of digital payment adoption.

Future investigations should broaden this framework through comparative and cross-contextual empirical studies. By comparing various digital wallet platforms, researchers can assess whether the identified user preferences are consistent across different services and user groups, whereas cross-country validation would offer stronger evidence of the framework's external validity. Additional studies might also incorporate multi-criteria decision analysis with Explainable AI (XAI) to create more transparent recommendation systems and use Structural Equation Modeling (SEM) or Bayesian methods to explore more complex behavioral relationships under conditions of uncertainty.

CONCLUSION

This study contributes to the core discussion on the adoption of digital financial services by creating a direct methodological link between behavioral psychology and system engineering. The main scientific advancement of this research is the development of technology adoption frameworks through the formal combination of the Technology Acceptance Model and Fuzzy Analytical Hierarchy Process. This combined analytical method theoretically enhances the explanatory power of traditional adoption models by converting abstract psychological concepts into measurable structural priorities. In doing so, the framework ties user acceptance behavior to specific infrastructural needs, illustrating how key factors such as perceived usefulness and perceived risk necessitate precise system configurations. Given the specific environmental conditions of this study, the empirical results are limited and do not assert universal applicability. The findings accurately represent the maturity level of the Indonesian digital wallet ecosystem and the distinct demographic traits of its current users. To thoroughly validate and broaden this integrated framework, future research should focus on testing across various platforms and cultural settings. Subsequent academic work should systematically compare these structural findings within different digital financial

ecosystems to establish wider external validity. Additionally, applying this hybrid evaluation model to other emerging technology fields is crucial for assessing its methodological flexibility and enhancing its predictive accuracy in complex decision-making scenarios.

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