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Determinants of Cashless Transaction Adoption among Rural Communities in Malaysia: An Empirical Study

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Abstract. This study investigates factors influencing the adoption of cashless transactions in rural Malaysian communities, focusing on four key determinants: infrastructure and connectivity, digital literacy, user-friendly interface design, and local merchant acceptance. Data were collected from 258 rural residents via a structured survey, and multiple regression analysis was used to examine the relationships between these factors and individuals' propensity to adopt cashless payment methods. The results reveal that infrastructure and connectivity ($\beta \approx 0.17$, $p < 0.01$), digital literacy ($\beta \approx 0.34$, $p < 0.001$), and user-friendly interfaces ($\beta \approx 0.21$, $p < 0.01$) each have a significant positive effect on the likelihood of adopting cashless payments. By contrast, local merchant acceptance ($\beta \approx 0.03$, $p = 0.678$) did not show a significant influence on adoption. The study's cross-sectional design and convenience sampling limit the generalizability of the findings, as rural communities can differ widely in infrastructure and culture. Nonetheless, the results suggest that initiatives to enhance rural digital infrastructure, improve residents' digital literacy, and design intuitive, easy-to-use payment interfaces will be more effective in promoting cashless transaction uptake than efforts focusing solely on increasing merchant acceptance. This study provides empirical evidence and insights to guide policies and strategies aimed at advancing digital financial inclusion in rural areas.

Keywords: Cashless adoption; Rural communities; Digital literacy; Technology Acceptance Model (TAM); Financial inclusion

1. Introduction

Globally, developing economies are rapidly transitioning toward cashless financial systems, propelled by advances in financial technology (fintech) and expanding digital infrastructure (Jain & Singhal, 2019). Unlike traditional cash dealings, cashless payment methods – such as mobile wallets, online banking, and debit or credit cards – offer enhanced convenience and security. They enable instantaneous financial transactions regardless of location and maintain digital records of spending, simplifying financial management and reducing risks like theft or loss (Chawla & Joshi, 2019). Malaysia exemplifies this global shift, having positioned itself as a frontrunner in digital finance through government initiatives like the MyDigital blueprint launched in 2021, which aims for a predominantly cashless economy and the digitization of all public service payments (Malaysia Digital Economy Corporation, 2021). Reflecting these efforts, Malaysian society has recently seen notable growth in digital payment usage and a corresponding decline in cash-dependent transactions (Bank Negara Malaysia, 2021). Despite this national push toward a cashless society, an urban-rural divide persists in both technological infrastructure and financial behavior. Urban residents typically benefit from readily available high-speed internet and a dense network of merchants accepting digital payments, whereas rural residents often face patchy connectivity and fewer opportunities or incentives to use cashless options. As a result, the penetration of cashless transactions in rural areas remains significantly lower than in urban centers, posing a challenge for inclusive financial development. Rural communities tend to confront distinct barriers to adoption, including inadequate network infrastructure, limited exposure and skills in using digital technologies, and entrenched cash-centric cultural practices (Singh & Srivastava, 2020). In other words, what may be taken for granted in urban settings – stable internet access, familiarity with fintech, and widespread merchant support for e-payments – cannot be assumed in rural environments.

Prior studies on digital payment adoption have predominantly focused on urban populations or general consumers, often highlighting factors like perceived usefulness, ease of use, social influence, and trust (frequently employing frameworks such as the Technology Acceptance Model or the Unified Theory of Acceptance and Use of Technology). Far fewer quantitative studies have zeroed in on rural populations, who may face different enablers and constraints. Some qualitative evidence suggests that rural users are hindered by infrastructural issues and lack of exposure to digital finance, but systematic data in the Malaysian rural context are limited. To address this gap, the present study concentrates exclusively on rural communities in Malaysia and examines the factors that influence their adoption of cashless transaction methods. The main objective is to identify and analyze the key determinants affecting whether rural residents embrace cashless payments. In particular, we investigate the impact of: (1) Infrastructure and Connectivity – the availability and reliability of internet and mobile network access; (2) Digital Literacy – users' ability to understand and utilize digital technologies; (3) User-Friendly Interfaces – the ease of use and intuitiveness of cashless payment platforms; and (4) Local Merchant Acceptance – the extent to which local shops and businesses accept cashless payments. These four factors were selected based relevant literature indicating they are likely influential in rural settings. We ground our examination in the Technology Acceptance Model (TAM) to understand how these external factors translate into perceived ease of use, perceived usefulness, and ultimately adoption behavior. This study contributes to the literature by providing empirical evidence from an under-represented population – rural Malaysian communities – thereby extending knowledge of digital finance adoption beyond the urban context. By pinpointing which factors have the greatest impact on cashless payment uptake in this environment, we not only test the applicability of TAM in a rural setting but also consider enhancements to it, where necessary, to include critical environmental factors (such as infrastructure). The findings of this research have practical significance as well. They offer guidance to policymakers and financial service providers on where to focus efforts to promote cashless transactions in rural areas. Ultimately, fostering greater adoption of cashless payments in rural communities can

improve financial inclusion and economic participation, aligning with Malaysia's digital economy goals and ensuring that the benefits of the cashless revolution are equitably distributed.

2. Literature Review

2.1. Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) provides a foundational theory for understanding user adoption of new technologies (Davis, 1989). TAM posits that two key perceptions – Perceived Ease of Use (PEOU) and Perceived Usefulness (PU) – drive an individual's attitude toward using a technology, which in turn influences their behavioral intention and actual usage. PEOU is defined as the degree to which a person believes that using a particular system would be free of effort, whereas PU is the degree to which one believes the system will enhance their performance or productivity. In simpler terms, if a technological application is easy to use and offers significant benefits, people are more likely to accept and use it. TAM has been widely applied and validated across domains, including online banking, e-wallets, and mobile commerce, often explaining a substantial portion of variance in users' intentions to adopt technology (Jain & Singhal, 2019). While TAM's core constructs are general, many studies extend the model by incorporating additional factors to account for contextual influences (Venkatesh & Davis, 2000). For example, researchers have introduced variables such as trust, perceived risk, and cost into TAM when examining financial technologies, to better capture the context of use. In an e-commerce setting, adding trust and privacy concerns has been shown to improve TAM's predictive power for online purchase intentions. In the context of mobile payments, personal traits like technological anxiety or innovativeness have also been integrated into TAM frameworks to explain adoption differences. These extensions suggest that TAM's core is robust but that the drivers of perceived usefulness and ease of use often depend on the environment and technology in question.

In rural contexts, applying TAM requires identifying the salient external factors that shape rural users' perceptions of how easy and how useful cashless payments would be in their lives. Rural populations differ from urban ones in terms of technology infrastructure availability, experience with digital services, and cultural attitudes toward technology and money. For instance, if internet connectivity is poor or unreliable, using a mobile payment app may be perceived as difficult or impractical, likewise, if few local stores accept digital payments, a cashless system might not be seen as useful to a rural user because it cannot be widely applied in daily transactions. Additionally, factors like trust in technology can be particularly significant in communities with limited exposure to digital finance; users who are unfamiliar with cashless systems may worry about fraud or errors. A study in rural India noted that what is technologically accepted in urban areas may not be readily accepted in rural areas due to differences in literacy and socio-economic status, and that incorporating trust and risk perceptions was necessary to explain rural customers' adoption of branchless banking (as implied by Kataria et al., 2021; see also Truong & Huyen, 2025 for an example of integrating trust into TAM). In this study, TAM provides the overarching framework: we assume that rural users will be willing to adopt cashless payment technologies if they find them easy to use and useful in their daily lives. We review each factor below and develop hypotheses about how they relate to cashless transaction adoption.

2.2. Infrastructure and Connectivity

Access to reliable infrastructure – especially electricity, internet, and mobile network coverage – is a fundamental requirement for digital payment systems to function. If a rural resident does not have consistent internet or cellular signal, even the most user-friendly e-wallet app will be perceived as cumbersome or unusable. Prior studies underline that deficient infrastructure is a major impediment to fintech adoption in rural regions. For instance, studies of the "rural digital divide" note that rural users often face infrastructural constraints like slower or no internet connectivity, which urban users rarely worry about (Salemink et al., 2017). In the context of cashless payments, evidence from developing countries shows the importance of network availability: in rural Bangladesh, a lack of network

infrastructure and frequent electricity outages significantly hindered the use of mobile banking services (Ashraf, 2022). Similarly, in rural Wales, gaps in broadband coverage have been linked to slower uptake of digital innovations even in sectors like agriculture (Bowen & Morris, 2019). These examples illustrate that without a minimum level of technical infrastructure, the perceived ease of using digital payments remains low – transactions might fail or be too slow – and the perceived usefulness is also diminished since one cannot reliably use the service when needed. In Malaysia's rural areas, infrastructure has improved in recent years (e.g. through government broadband initiatives), but coverage remains spotty in certain locales (Tahir et al., 2016). If residents have to travel to town just to get a stable signal, or if connections frequently drop, using cashless payment apps becomes frustrating or impractical. Conversely, when connectivity is strong and power supply is stable, digital transactions can be completed quickly and reliably, adding to the perceived usefulness of cashless options (the service works whenever needed) and perceived ease of use (transactions go through without hassle) (Abdul Ghaffar, 2022). Under the TAM framework, robust infrastructure can be viewed as an external enabling condition that positively influences where it reduces the effort required (making the system seem easier) and ensures the system is functional and available (making it more useful).

2.3. Digital Literacy

Digital literacy refers to an individual's ability to effectively find, understand, and use digital technologies – in this case, the skills and knowledge to operate smartphones, mobile apps, and electronic payment platforms. Rural populations often have lower exposure to digital tools than their urban counterparts, due to differences in education, availability of training resources, and daily needs. A person with low digital literacy may find using a mobile payment application intimidating or confusing, which would reduce their perceived ease of use of such technology (Hasin & Nasir, 2021). Prior research consistently supports the critical role of user competence in technology acceptance. For example, a study in rural Nigeria observed that personal characteristics like education level (a proxy for literacy) significantly affected the adoption of cashless policies in rural areas (as summarized by (Okiridu & Ogwutum, 2025). In Malaysia, a qualitative study of rural youth found that lack of digital literacy was a primary barrier to embracing cashless transactions – those youths who were more tech-savvy were optimistic and able to engage in cashless methods, whereas those who lacked knowledge were hesitant (Kassim et al., 2024). Similarly, a survey in a rural state of Malaysia reported that awareness and understanding of e-wallets had a significant influence on acceptance levels (Izzah et al., 2021). These findings align with TAM extensions that include factors such as self-efficacy or facilitating conditions: essentially, if users feel capable of using the technology, they are more likely to find it easy to use and to see its usefulness in their lives. In our study, digital literacy encompasses both general education and specific familiarity with digital devices and applications. We anticipate that rural individuals with higher digital literacy (for example, those who can navigate smartphone apps and troubleshoot basic issues) will find it easier to adopt cashless systems, as they can overcome minor technical hurdles and fully utilize the features available. Such individuals are also likely to be more aware of the advantages of cashless payments (e.g. they might know about promotions or features that make cashless convenient), thereby perceiving greater usefulness. Thus, higher digital literacy should positively influence the adoption of cashless transaction methods in rural communities.

2.4. User-Friendly Interfaces

Even with good infrastructure and sufficient user skills, the design of the cashless payment system itself plays a crucial role in adoption. User-friendly interfaces refer to how easy, intuitive, and accessible the technology is for the user. In TAM terms, this directly feeds into perceived ease of use – if the application or system is poorly designed or overly complex, users will perceive it as difficult to use and may be deterred from using it regularly. Conversely, a simple, well-designed interface that is tailored to the user's needs can lower the effort required and improve the user experience, thus encouraging adoption.

The literature on technology adoption emphasizes simplicity and clarity in design as important facilitators. For instance, researchers have found that the ease of navigating mobile payment interfaces significantly increases users' intention to adopt such services (Chawla & Joshi, 2019). Reducing complexity in the user interface lowers cognitive burden and anxiety, which leads to higher acceptance of the technology. In a rural context, interface design might need to account for language preferences, cultural familiarity, and varying literacy levels of users. A study in rural India highlighted that digital financial apps should use local language and straightforward terminology to improve uptake among rural users (Azeez & Akhtar, 2021). If the app uses jargon or assumes knowledge that the user doesn't have, it can alienate or confuse them. By contrast, clear menus, readable fonts, and guided prompts (for example, tutorials or help in the local language) can make a big difference in helping first-time users succeed. In Malaysia, many popular cashless payment apps are designed with an urban, relatively tech-savvy user in mind, and may not be fully optimized for rural elderly or less-educated users. Ensuring features like prominent Malay language options (or other local languages in certain regions), simple menu structures, and offline support or low-bandwidth modes could improve usability for rural customers (Prasad et al., 2024) Prior research suggests that an easy-to-use interface not only reduces the effort of transactions but also enhances user satisfaction and trust (Judijanto & Wardhani, 2024). In short, if a rural user finds the cashless payment platform "friendly" and hassle-free, they are more likely to try it and continue using it. Therefore, we expect that more user-friendly interface design will positively influence the adoption of cashless transactions among rural residents. A platform that is perceived as intuitive and accessible should lead to higher acceptance and sustained use of cashless payment methods.

2.5. Local Merchant Acceptance

The acceptance of cashless payment methods by local merchants and businesses is another factor that could be crucial in determining how useful those methods are to consumers. If only a few places in a rural town accept digital payments, a resident might not see much point in adopting an e-wallet or debit card – cash would remain the default for most daily transactions. However, if many shops, market stalls, and service providers in the community start to accept (or even encourage) cashless payments, then adopting those methods becomes more attractive and practical for consumers. This dynamic can be viewed through the lens of network externalities: the value of a payment system increases as more people – including merchants – use it. In urban settings, studies have shown that merchant adoption and peer usage create a supportive ecosystem that drives individual adoption. For example, among urban young adults in Malaysia, seeing many merchants and peers use e-wallets had a positive impact on individuals' intention to use them (Yang et al., 2021). This aligns with constructs like subjective norm in extended TAM models – essentially, if important others (including the businesses one frequents) endorse or facilitate a technology, a person is more likely to use it. In Ghana, researchers noted that the success of cashless systems partly depends on how widely local merchants adopt them, as this builds trust and familiarity in the community (Apau et al., 2019). In rural areas, merchant acceptance might play out somewhat differently. Many rural economies have a large informal sector where transactions occur at roadside stalls, small village shops, or between individuals (e.g. buying produce directly from a farmer) (Ferris et al., 2014). These transactions often lack the infrastructure for electronic payments, and the merchants themselves may be hesitant to adopt cashless methods due to fees, lack of knowledge, or limited demand (Irianto & Chanvarasuth, 2025). Nonetheless, merchant acceptance was identified as an important consideration by rural respondents in our preliminary conversations – for example, some villagers mentioned they would be more inclined to use e-wallets "if more shops here took them." Recognizing this, government and industry initiatives in Malaysia's rural areas (such as programs under the national e-payment platform DuitNow) have begun encouraging small merchants to use QR code payments. The uptake is still ongoing, but there is a push to increase the number of merchants in rural towns that can accept cashless payments. In TAM terms, this factor relates to perceived usefulness: the more ubiquitous digital payment options are in one's environment, the more useful it is to the consumer

to have an e-wallet or card, since they can use it in many situations. It also carries a social influence aspect: when local shops display signs like "We Accept e-Wallets," it not only enables usage but also implicitly encourages customers to try those methods. Therefore, we expect that greater acceptance of cashless payments among local merchants will positively influence rural residents' willingness to adopt cashless transaction technologies.

2.6. Research Framework and Hypotheses

Based on the above discussion, we propose a conceptual framework in which the four factors – infrastructure & connectivity, digital literacy, user-friendly interface design, and local merchant acceptance – are posited to affect the adoption of cashless transactions in rural areas. This framework is grounded in TAM: the first three factors primarily facilitate perceived ease of use (by reducing external barriers and effort), and the fourth factor contributes to perceived usefulness (and to some extent, social norms) of cashless systems. Together, these perceptions and conditions drive the behavioral adoption of cashless payment methods.

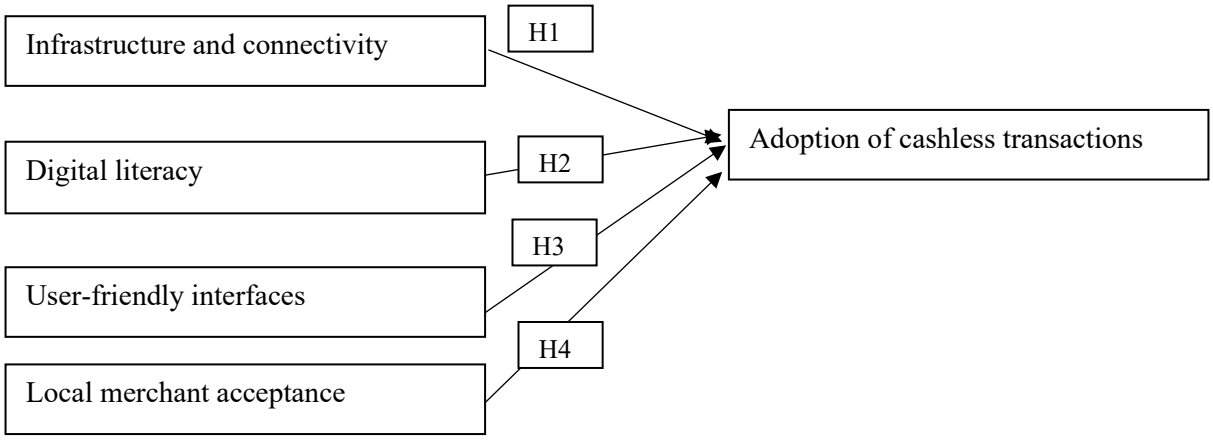

Fig.1: Conceptual Framework

As provided in *Figure 1* depicting the four hypothesized determinants of cashless transaction adoption in rural communities. Infrastructure & connectivity, digital literacy, and user-friendly interfaces are expected to enhance perceived ease of use of cashless systems, while local merchant acceptance mainly contributes to perceived usefulness. These factors collectively influence the likelihood that rural residents adopt cashless payment methods.

In line with this framework, we formalize the following hypotheses:

- H1: Infrastructure and connectivity will have a positive effect on cashless transaction adoption in rural communities
- H2: Digital literacy will have a positive effect on cashless transaction adoption in rural communities.
- H3: User-friendly interfaces will have a positive effect on cashless transaction adoption in rural communities.
- H4: Local merchant acceptance will have a positive effect on cashless transaction adoption in rural communities.

3. Methodology

3.1 Research Design and Sample

This study employed a quantitative, cross-sectional survey design to investigate the determinants of cashless transaction adoption among rural communities in Malaysia. The research focused on a rural district in northern side of Malaysia. The area includes a modest town center with basic digital facilities and is surrounded by traditional villages, offering a relevant context to study the interplay between digital readiness and infrastructural limitations. The study targeted rural residents aged 18 and above who had access to at least minimal banking services or owned a mobile device. Due to logistical constraints and the absence of a comprehensive sampling frame for scattered rural populations, a non-probability convenience sampling technique was used. While this method restricts generalizability, it allowed for the efficient recruitment of respondents across multiple access points, especially when facilitated through local community structures.

Data collection was conducted on 2023 using a dual-mode strategy. The first mode involved distributing printed questionnaires at local community centers, small businesses, and shops with the assistance of village heads and community representatives. Research assistants provided support on-site, ensuring that older or less digitally literate respondents could participate. The second mode employed an online version of the questionnaire created via Google Forms and disseminated through popular communication channels such as WhatsApp groups and Facebook pages frequented by local residents. This approach captured the younger and more digitally connected segment of the population. Participation in the survey was voluntary, and informed consent was obtained. All responses were anonymous, and no identifiable personal data were collected. A total of 317 responses were received. After removing incomplete and inconsistent responses (e.g., uniform answers across all items), 258 valid cases were retained for analysis. This sample size exceeded the threshold typically required for multiple regression analysis, with four predictors, a minimum of 82 observations would suffice, and the final sample of 258 provided robust statistical power. For the purpose of this study, "rural" was operationally defined as a locality outside city or metropolitan zones, consistent with the Malaysian administrative classification. While this study provides insights into a typical semi-rural setting in Peninsular Malaysia, findings should be interpreted within the contextual limits, as more remote areas (e.g., in Sabah and Sarawak) may display different infrastructural and behavioral characteristics.

3.2 Survey Instrument and Measures

The instrument used in this study was a structured questionnaire adapted from validated scales found in recent empirical studies. All items were measured using a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). The questionnaire was developed in English and then translated into Bahasa Malaysia through a bilingual review process to ensure clarity, cultural appropriateness, and linguistic accuracy. Cashless transaction adoption, the dependent variable, was measured using four items adapted from Al-Qudah et al. (2024) and Raj et al. (2023), which assessed both behavioral intention and usage preference. Example items include: “I intend to increase my use of cashless payment methods in the near future” and “Whenever possible, I prefer to pay without using cash.” These items reflect both psychological readiness and actual behavior, particularly relevant for rural users whose choices may be constrained by local availability. Infrastructure and connectivity were assessed using five items based on the Cashless Transaction Adoption Model (CTAM) developed by Raj et al. (2023), who emphasized the role of technological infrastructure in enabling cashless transactions. Statements included: “I have access to a stable internet or mobile network when making digital payments,” and the reverse-coded item, “Poor internet or phone connectivity makes it hard for me to use cashless payments.” Digital literacy was measured using four items adapted from Al-Qudah et al. (2024), focusing on digital confidence, knowledge, and familiarity. Items included: “I feel confident using smartphone apps on my own,” “I am knowledgeable about different cashless payment methods,” and a reverse-coded item: “I find it difficult to learn how to use new digital payment systems.” These measures are reflective of current approaches to assessing consumer readiness for fintech

adoption in rural communities. User-friendly interface perceptions were evaluated using five items also adapted from Raj et al. (2023), assessing whether digital tools are intuitive and accessible. Sample statements included: "The mobile payment applications I use are user-friendly," "The interface (language and layout) of these apps is easy to understand," and the reverse-coded, "Cashless payment systems are too complicated to use." These items were generalized to encompass a variety of platforms, including mobile wallets and banking apps. Local merchant acceptance was measured using five items drawn from the same contemporary studies, reflecting perceptions of payment acceptance in the community. Sample statements included: "Many shops and vendors in my area accept cashless payments," "Local businesses are increasingly encouraging cashless payments (e.g., displaying QR codes or signs)," and the reverse-coded item, "I often cannot use cashless payments because the vendor only accepts cash." These items help gauge the extent of ecosystem maturity in rural commercial environments. All adapted scales have been previously validated in recent peer-reviewed studies, thus eliminating the need for separate pilot testing. The adaptation process involved contextual modifications to ensure relevance to the Malaysian rural context, including adjustments to language clarity and examples to reflect local practices.

3.3 Survey Instrument and Measures

Data analysis was performed using IBM SPSS Statistics (Version 26). Descriptive statistics were first computed to provide a profile of respondents and the central tendencies of key variables. To assess reliability, Cronbach's alpha values were calculated for each multi-item scale. All constructs recorded alpha values above 0.70, indicating satisfactory internal consistency. Construct validity was tested using exploratory factor analysis (EFA) with principal components extraction and varimax rotation. The analysis confirmed that items loaded strongly on their intended factors with minimal cross-loadings. Additionally, Average Variance Extracted (AVE) values exceeded the 0.50 benchmark, demonstrating both convergent and discriminant validity. Correlation analysis using Pearson coefficients was conducted to examine preliminary relationships among key variables and detect potential multicollinearity. All independent variables were positively and significantly correlated with cashless adoption. Variance inflation factor (VIF) values were below 2 for all predictors, indicating no multicollinearity concerns. To evaluate the hypotheses, multiple linear regression analysis was conducted with cashless transaction adoption as the dependent variable. The four predictors—infrastructure and connectivity, digital literacy, user-friendly interface, and local merchant acceptance—were included simultaneously in the model. Regression diagnostics showed that assumptions of linearity, normality, homoscedasticity, and independence of residuals were met. No influential outliers were detected, as Cook's distance values were well below the critical threshold of 1.0. Interaction effects were explored to assess whether demographic factors moderated the relationship between predictors and the dependent variable. For instance, an interaction term between digital literacy and age was created to examine whether older individuals with higher digital literacy showed different adoption patterns. Another interaction was tested between infrastructure and merchant acceptance. However, none of the interaction terms reached statistical significance or improved the model's explanatory power, indicating that the relationships among the core constructs were stable across subgroups.

In sum, the methodological approach adopted in this study provides a valid and reliable framework for identifying key determinants of digital financial adoption in rural Malaysia. The subsequent section presents the analytical results and discusses their implications within both theoretical and practical contexts.

4. Results & Discussion

4.1. Respondent profile

Before delving into the hypothesis tests, it is useful to highlight a few patterns in the respondent demographics and their current usage of cashless payments. As noted, our sample was skewed towards adults over 25. We observed that the younger participants (those in their late teens or early twenties, who constituted a minority of the sample) tended to report somewhat higher usage of cashless methods in daily life compared to the older participants. For example, among respondents aged 25 or below, a higher proportion indicated that they "often prefer to pay without cash" in routine transactions, whereas older respondents were more likely to still favor cash. This is an expected pattern, as younger people might be more open to new payment technologies and have had more exposure to e-wallets (especially if they spent time in urban areas for education). However, given that younger respondents were relatively few, these age differences did not dominate the data. Statistically, age had a small negative correlation with the adoption score ($r \approx -0.15$, $p < 0.05$), indicating that older individuals in our sample were slightly less inclined towards cashless payments, but age alone explains little of the variance when other factors are considered.

Gender did not show a significant difference in cashless adoption in our sample. Both men and women had very similar average scores on the adoption scale (around 5.1–5.2 on the 7-point scale), and a t-test confirmed no significant gender gap ($p = 0.67$). This suggests that, at least in this rural context, being male or female by itself was not a differentiating factor in willingness to use cashless payments once access and literacy are accounted for.

Education level showed a modest positive correlation with the adoption measure ($r \approx 0.22$, $p < 0.001$), respondents with higher formal education tended to have slightly higher intentions to use cashless methods. This is likely linked to digital literacy – indeed, education was moderately correlated with our digital literacy construct (those with more education generally rated themselves higher in digital skills). It reinforces the idea that educational background (and by extension, exposure to technology) can facilitate adoption, although education alone does not directly cause adoption. In our regression analysis, the effect of education is expected to be captured indirectly through digital literacy.

In terms of current cashless usage behavior, we found that about 40% of respondents said they already use some form of cashless payment at least a few times per month. The most common forms of cashless usage reported were debit card transactions (e.g., at supermarkets or petrol stations) and use of the Touch 'n Go card (a stored-value card popular for public transport and increasingly accepted at some retail outlets). Around 15% reported using mobile e-wallet apps (such as GrabPay, Boost, or ShopeePay) on a frequent basis. Notably, a majority (approximately 60%) still relied primarily on cash for daily transactions (like buying groceries at local shops or markets). These figures underscore that we are observing a community in the early stages of cashless adoption: while a significant number have started using digital payments in some capacity, cash remains the dominant mode for everyday commerce in these rural areas. This context validates the importance of studying adoption determinants – there is substantial room to increase cashless usage, and understanding the barriers and drivers is key to informing initiatives.

Overall, these descriptive observations suggest that some demographic factors (like younger age and higher education) coincide with higher cashless adoption, but none of the basic demographics show effects large enough to override the main factors we are interested in. We now turn to the hypothesis testing to see how infrastructure, literacy, interface, and merchant acceptance explain variance in cashless adoption when considered together.

4.2. Reliability and Validity of Measures

All the multi-item constructs in our survey demonstrated strong internal consistency. Table 1 reports the Cronbach's alpha values for each scale. As shown, the Cronbach's alpha for the Cashless Adoption scale (4 items) was 0.924, indicating excellent reliability. For the independent variable scales, alpha values ranged from 0.84 to 0.87, all well above the 0.70 threshold. This confirms that the items for each construct are measuring a cohesive underlying concept (e.g., the five infrastructure items co-vary well, as do the literacy items, etc.).

Table 1. Cronbach's alpha

Construct	Cronbach's α	No. of Items
Cashless Transaction Adoption	0.924	4
Infrastructure & Connectivity	0.855	5
Digital Literacy	0.862	4
User-Friendly Interfaces	0.836	5
Local Merchant Acceptance	0.873	5

To assess construct validity, we performed an exploratory factor analysis on the 19 items representing the four independent variables. The Kaiser–Meyer–Olkin measure of sampling adequacy was 0.88 and Bartlett's test of sphericity was significant ($\chi^2(171) = 1632.5$, $p < 0.001$), indicating that the data were suitable for factor analysis. The rotated component matrix revealed four distinct factors with eigenvalues greater than 1, which together explained about 68% of the total variance. Each item loaded most strongly on its intended factor (all primary loadings above 0.70) with minimal cross-loading (no secondary loading exceeded 0.30). For example, all items related to infrastructure (e.g., network stability) clustered on one factor, all digital literacy items on another, and so forth, matching our theoretical constructs. We calculated the Average Variance Extracted for each construct: Infrastructure & Connectivity had AVE ≈ 0.59, Digital Literacy ≈ 0.61, User-Friendly Interfaces ≈ 0.57, and Local Merchant Acceptance ≈ 0.63. All AVE values were above the recommended 0.50, supporting convergent validity. Moreover, we checked that the square root of each construct's AVE was greater than its correlations with other constructs, which held true, supporting discriminant validity. In summary, these results give us confidence that our survey measures are both reliable and valid. The constructs are empirically distinguishable yet moderately correlated in sensible ways (for instance, the correlation between digital literacy and infrastructure availability was positive, as one might expect, since those with better connectivity may also tend to be slightly more digitally skilled over time). With the measurement quality established, we proceed to the analysis of respondents' characteristics and hypothesis testing

4.3. Regression Analysis

Table 2. Multiple Regression

Predictor Variable	Standardized β	t-value	p-value
(Constant)	–	2.109	0.036 *
Infrastructure & Connectivity	0.172	2.715	0.007 **
Digital Literacy	0.342	5.438	< 0.001 **
User-Friendly Interfaces	0.211	2.850	0.005 **
Local Merchant Acceptance	0.026	0.415	0.678 (n.s.)

Model fit: $F(4, 253) = 250.9$, $\mathbf{p} < 0.001$; $R^2 = 0.797$, Adjusted $R^2 = 0.785$. (*Note:* $p < 0.05$ marked with *, $p < 0.01$ marked with **; n.s. = not significant.)

The regression model in Table 2, as a whole was highly significant ($F = 250.9$, $p < 0.001$), indicating that collectively the four factors explain a substantial portion of the variance in cashless adoption among these rural respondents. The R^2 value of 0.797 suggests that about 79.7% of the variance in the adoption score is accounted for by the linear combination of infrastructure, digital literacy, interface usability, and merchant acceptance. Even after adjusting for the number of predictors, the adjusted R^2 is 0.785 (78.5%), which is still very high for behavioral research. This high R^2 implies that our model captured

the key influences on the adoption variable in this context – which is perhaps not surprising given that those who were adopting tended to have multiple enabling factors in place, whereas those not adopting often faced several barriers concurrently.

Infrastructure & Connectivity had a positive and statistically significant coefficient ($\beta = 0.172$, $t = 2.715$, $p = 0.007$). This supports H1. It indicates that, holding other factors constant, rural residents who reported better internet/mobile connectivity and infrastructure were more likely to adopt cashless payment methods. In practical terms, an increase of one standard deviation in the infrastructure perception score is associated with roughly a 0.17 standard deviation increase in the adoption score. This effect size is moderate. It confirms that having reliable network access is an important facilitator of going cashless. Those villagers who feel that connectivity is not a problem tend to also be the ones using or willing to use digital payments. Our result reinforces fundamental knowledge from "digital divide" literature: bridging the infrastructural gap is a prerequisite for rural digital inclusion (Salemink et al., 2017). In our sample, those who had decent connectivity at home or in their village were far more inclined to use cashless options, presumably because they could actually complete transactions without frustration or failure. This finding echoes studies like Bowen and Morris (2019) in Wales, which noted that poor connectivity hindered the uptake of digital innovations. In TAM terms, we can view infrastructure as an external facilitating condition that enables perceived ease of use – if the network works seamlessly, using an e-wallet app feels easy; if not, even a good app becomes cumbersome, and ease-of-use perceptions plummet, discouraging use.

Digital Literacy emerged as the strongest predictor among the four, with a standardized coefficient $\beta = 0.342$ ($t = 5.438$, $p < 0.001$). This provides strong support for H2. High digital literacy significantly increases the likelihood of adopting cashless methods. In fact, digital literacy had roughly double the impact of infrastructure in terms of standardized beta. This means that, in our sample, knowing how to use technology and being comfortable with it was a particularly critical factor in deciding to use cashless payments. A one standard deviation improvement in digital literacy corresponded to about a one-third standard deviation higher adoption score, all else equal. Substantively, this suggests that efforts to improve digital skills and confidence could have a large payoff in terms of getting more rural users to go cashless. This underscores that human capital – in the form of technology know-how and confidence – is perhaps the key to unlocking digital finance usage in rural areas. Our finding resonates with qualitative insights from Kassim et al. (2024) who emphasized that rural youth identified lack of digital know-how as a major barrier. We have demonstrated this for a broader rural population: those who are more digitally literate are *much* more likely to adopt cashless payment methods. This makes intuitive sense and is consistent with TAM's notion that ease of use will be greater for those who feel capable with technology. Our work aligns with findings from other contexts that highlight technical skills as crucial for adoption. For instance, a study in Ghana found that education and familiarity with technology facilitated the shift to cashless systems (Apau et al., 2019). Goh & Nguyen (2022) also pointed out that in a Malaysian context, technical skill and knowledge were decisive factors for adopting cashless payments. The strong role of digital literacy in our model suggests that initiatives aiming to increase rural cashless adoption should prioritize training and education (Kassim et al., 2024 .

User-Friendly Interfaces also showed a significant positive relationship with adoption ($\beta = 0.211$, $t = 2.850$, $p = 0.005$), supporting H3. This indicates that the more the respondents found the cashless systems easy to use and well-designed, the more likely they were to use them. Although our measurement of this factor is based on user perceptions (and thus could be influenced by whether they actually used the systems), the result underscores a principle of TAM: perceived ease of use, which in this case is driven by interface design and usability, contributes to acceptance. The standardized effect size (~0.21) is in the small-to-moderate range, suggesting it is an important factor, though not as dominant as digital literacy. It is worth noting that interface perception can be somewhat endogenous (people who use the apps more might come to find them easier over time), but even so, the clear association implies that if the technology is seen as user-friendly, adoption is higher. This result

highlights that even if infrastructure is available and users have basic skills, the design of the payment application itself can encourage or impede usage. If an app is too complicated, not localized in language, or requires many cumbersome steps, rural users (especially those not very patient with new tech) may quickly give up on it (Singh & Srivastava, 2020; Shaikh & Karjaluoto, 2015). On the other hand, if the app is intuitive – perhaps using clear visuals, simple instructions, and minimal required steps – users are more likely to keep using it and integrate it into their routines. Our participants who agreed that the interfaces were easy to use were indeed more likely to be adopters. This aligns with a broad swath of technology adoption literature that stresses perceived ease of use as a determinant of attitude and intention (Davis, 1989; Chawla & Joshi, 2019). For rural users, the threshold for what is considered "easy to use" might need special consideration. Some of our older respondents commented that they found certain banking apps confusing or "not made for people like me." These anecdotes suggest that mainstream fintech apps might inadvertently be leaving behind less experienced users. Practical implications of this finding are straightforward: fintech providers and developers should invest in tailoring their user interfaces for inclusivity. This could include offering interfaces in the local language by default, using larger icons and text for those with limited literacy or eyesight, providing an option for a simplified interface mode (covering essential functions with clear one-step actions), and ensuring that help or customer support is easily accessible. Some e-wallet providers have begun to conduct outreach in communities, demonstrating how to use their apps – continuing and expanding such efforts will likely pay dividends. Essentially, improving the *usability* of the technology can directly reduce the effort and uncertainty for new users, thus lowering the barrier to adoption.

Our findings indicate that local merchant acceptance of cashless payments did not have a significant effect on the adoption of cashless transactions among rural users ($\beta = 0.026$, $t = 0.415$, $p = 0.678$). This result contradicts Hypothesis 4 (H4), which anticipated a positive relationship. After accounting for other variables like infrastructure, digital literacy, and interface usability, the presence of cashless payment options at local merchants did not predict whether individuals would adopt such methods. This is a particularly intriguing result, as it goes against prior research and established models such as the Diffusion of Innovation Theory and extensions of the Technology Acceptance Model (TAM), which often highlight external factors like vendor or peer influence as important adoption triggers (Yang et al., 2021). Altounjy et al. (2020) stated in their paper, more mature digital payment ecosystems, widespread merchant acceptance can enhance perceived usefulness and reduce friction in everyday usage, thereby driving user uptake. However, our study suggests that rural Malaysia may be at a much earlier stage of the adoption curve, where foundational factors matter more than broader ecosystem readiness. In early adoption phases—especially in underserved or technologically lagging regions—users prioritize infrastructure, knowledge, and ease of use over social or environmental reinforcements. Many rural consumers are likely still grappling with access issues, unfamiliarity with digital interfaces, and a lack of confidence. In such contexts, the presence of cashless options at a handful of shops does little to change user behavior if they cannot access, understand, or trust the system (Vishwakarma et al., 2024).

Furthermore, we found no signs of multicollinearity distorting this result. The correlation between merchant acceptance and infrastructure was moderate (around $r = 0.45$), which suggests a distinct and separable influence. Interaction term testing—such as whether merchant acceptance matters more in areas with good connectivity—also yielded non-significant results ($p > 0.3$). This reinforces that merchant availability does not function as a conditional enabler in the current context. Historically, most small vendors in rural areas have relied on cash. If the shift toward e-payments is recent or uneven, people may continue to behave as if nothing has changed, even if some shops have upgraded their systems. This "perception lag" can mask incremental progress and mute the influence of emerging payment networks. Moreover, a threshold effect may be at play. If only a few merchants in a village accept cashless payments—such as the petrol station or a supermarket—then residents might still see cash as more practical. This conservative behavior, while rational in a limited ecosystem, weakens the

potential network effects that merchant adoption is expected to produce (Bounie, Camara, & Galbraith, 2024). Theoretically, this result has implications for how TAM is applied in rural and developing contexts. While TAM extensions often incorporate social influence or facilitating conditions as key constructs, our data suggest these may not be activated until later stages of adoption (Venkatesh et al., 2003). At present, rural users seem more influenced by internal enablers (e.g., skills and access) rather than external cues from peers or vendors. This supports the view that technological feasibility must precede social normalization in technology diffusion.

Importantly, our findings do not imply that merchant acceptance is irrelevant. On the contrary, we believe its role may become critical in the next stage of the adoption process. Once infrastructure and literacy gaps are narrowed, and users feel comfortable with digital tools, the availability of merchants will likely become a stronger determinant of sustained use. Additionally, although we did not include a dedicated "trust" variable, our results align with past research suggesting that security concerns may moderate the effect of merchant acceptance (Yeboah et al., 2020). Rural users may still harbor doubts about the safety of digital transactions, which in turn reduces their willingness to adopt—even when merchants accept it. Anecdotally, some respondents expressed fears of fraud, accidental overcharges, or irreversibility of failed transactions. Such concerns cannot be addressed merely by increasing the number of accepting merchants; trust-building efforts are also necessary.

In sum, our analysis reveals that local merchant acceptance, while intuitively important, does not currently play a significant role in cashless adoption among rural Malaysians. This finding emphasizes the importance of foundational enablers such as infrastructure, literacy, and usability. It also suggests that adoption processes in rural settings may not mirror those in urban or developed environments, where network effects and social influence have stronger predictive power. Policymakers should therefore prioritize the user-side enablers first. Merchant expansion, though necessary, will only become impactful once rural users are empowered and ready to use cashless technologies with confidence.

5. Conclusion

This study investigated the key factors influencing the adoption of cashless transactions in rural Malaysian communities, contributing to the ongoing discourse on financial digitalization in underserved regions. The findings offer several important theoretical and practical implications. Infrastructure connectivity, digital literacy, and user-friendly interface design emerged as significant enablers of adoption, whereas local merchant acceptance, though commonly assumed to be influential, did not show a significant direct effect in this context. From a policy and implementation perspective, the results underscore the necessity of prioritizing access to stable and reliable digital infrastructure. Despite various national initiatives aimed at expanding network coverage, many rural regions still experience intermittent connectivity or lack consistent access to electricity—both of which are fundamental prerequisites for digital participation. Efforts to extend broadband and mobile network access must be accompanied by support systems that ensure continuity of service, especially in geographically remote or economically marginalized areas. Without a solid infrastructure foundation, other interventions are likely to be undermined, regardless of their design or intent. Equally critical is the role of digital literacy in enabling individuals to engage meaningfully with digital financial tools. This study reaffirms the importance of equipping rural users with the necessary skills to navigate digital platforms confidently. Formal training programs, informal community workshops, and peer-led digital outreach initiatives could play a pivotal role in demystifying the use of mobile payment applications. These programs should not only address technical know-how but also emphasize practical, everyday use cases that are directly relevant to the rural lifestyle. Language accessibility is essential, with materials delivered in Bahasa Malaysia and, where necessary, in local dialects to ensure inclusive reach and comprehension.

In tandem with improving user capabilities, attention must also be given to the interface design of financial applications. Many current platforms assume a baseline of digital familiarity, which can

alienate novice users. Redesigning these interfaces to accommodate first-time users—through simplified navigation, clearer icons, and step-by-step guidance—can reduce cognitive friction and increase user confidence (Jayashree, 2023). Additionally, customer support must be readily available through accessible and familiar channels such as WhatsApp or call-in centers operated in local languages. This human support element is vital in ensuring that users feel secure and supported during their initial engagement with cashless technologies. Beyond access and usability, the issue of trust emerged—albeit indirectly—as a potentially powerful barrier to adoption. The absence of a trust-specific variable in this study does not negate its importance; rather, the qualitative dimensions of our findings suggest that many rural residents remain wary of digital transactions due to fears of fraud, technical glitches, or data misuse. It is therefore essential that stakeholders address this latent anxiety. Public education campaigns should be developed to raise awareness of digital payment safeguards, including authentication processes, consumer protections, and recourse options in cases of error. Sharing positive experiences from peers or respected figures within the community can also help normalize digital payment behavior and mitigate apprehensions (Graf-Vlachy & Buhtz, 2017). Importantly, trust-building must be treated not as a one-time effort but as a continuous component of digital financial inclusion strategy.

Although merchant acceptance was not statistically significant in this study, it remains a necessary part of the long-term equation. Its current insignificance likely reflects the sequence of adoption readiness, where user-side capability must be established before ecosystem effects such as peer usage and social norms become influential (Graf-Vlachy & Buhtz, 2017). Once rural users become more familiar with and reliant on digital payments, the availability of accepting merchants will become more salient (Jayaraj & Sarkar, 2024). Future initiatives should thus maintain efforts to encourage merchant adoption but do so in parallel with demand-side interventions. Coordinated strategies, such as local "cashless campaigns" that combine consumer training with temporary merchant discounts, can create momentum on both sides of the transaction and bridge the gap that often exists between supply and demand. Comparatively, the results offer a useful contrast to urban-focused studies where social influence, peer behavior, and merchant networks often play a more central role. In urban environments, digital payment systems are embedded in daily life, and users are often influenced by their peers or the ubiquity of the technology.

The study is not without its limitations. It employed a cross-sectional design and relied on convenience sampling within a single district, which restricts the ability to generalize findings across the diverse landscape of rural Malaysia. Some communities, particularly in East Malaysia or interior regions, may face even greater infrastructural and cultural challenges that influence digital payment behaviors differently. In addition, several key constructs—such as merchant acceptance and interface usability—were measured based on user perceptions, which introduces potential bias. Trust and security concerns, while acknowledged in the discussion, were not formally operationalized in the model, leaving room for further inquiry into their precise impact on adoption behaviors.

Given these limitations, future research would benefit from longitudinal designs that observe the same population over time to assess how adoption trajectories evolve with changing infrastructure, skills, and ecosystem maturity. Comparative studies between rural and urban users, or between rural regions with varying degrees of development, could further clarify which adoption factors are context-dependent and which are universally significant. More importantly, incorporating constructs such as perceived security and trust directly into the model would offer a more comprehensive picture of the psychological and cultural dimensions of digital adoption. Qualitative methods—such as interviews or ethnographic case studies—could complement the quantitative findings by uncovering the nuanced beliefs and emotions that shape user behavior. There is also great potential in intervention-based research. Field experiments or pilot programs that introduce specific measures—like targeted literacy workshops, interface redesigns, or localized trust campaigns—can generate causal insights that inform large-scale rollouts. For instance, implementing a digital literacy program in one village and comparing

outcomes with a control village could illuminate the direct effects of education on adoption. Likewise, enhancing internet access in selected communities and tracking subsequent adoption behaviors would yield actionable data on the infrastructure-adoption relationship.

In conclusion, the journey toward a cashless rural Malaysia is complex and multifaceted. This study demonstrates that the foundation of such a journey lies not in merchant-side readiness alone, but in user empowerment. It is only when individuals have the access, skills, and confidence to engage with digital tools that ecosystem factors—such as merchant availability—begin to matter. Therefore, the path to digital financial inclusion must start with the user. Stakeholders must focus on reducing structural barriers, building digital capacity, simplifying technological interfaces, and fostering trust. These efforts, taken together, create the enabling environment where cashless technologies can not only exist but thrive. As readiness expands, the momentum will naturally shift toward ecosystem expansion, including merchant integration and peer-driven network effects. They reflect the current state of rural digital adoption and provide a direction for those designing the next stage of Malaysia's cashless future. Ensuring that rural voices are heard, respected, and supported in this transition is not only a matter of technological policy—it is a matter of inclusive and equitable development.

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