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Determinants of Consumers' Intention to Use QR Code-Based Intelligent Packaging on Food Products: Evidence from the Indonesian Market

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ABSTRACT

This study examines the factors influencing consumers' intention to use intelligent packaging based on QR Code technology for product authenticity verification in the Indonesian food sector, using the Value-based Adoption Model (VAM). The proposed model integrates seven core constructs: perceived usefulness, perceived enjoyment, perceived informativeness, perceived technicality, perceived fee, perceived privacy risk, and perceived value as a key mediating variable influencing intention to use. Data were collected from 263 respondents through an online questionnaire, with 249 valid responses analyzed using Partial Least Squares-Structural Equation Modeling (PLS-SEM). The study supports five out of seven hypotheses, with perceived informativeness having the strongest indirect effect on adoption intention through perceived value. Perceived technicality and usefulness also positively influenced value, while perceived enjoyment and privacy risk were not supported by the data. A slight price increase negatively affected perceived value. Overall, perceived value mediated the relationship between technology benefits, costs, and adoption intention. The study extends the VAM framework in intelligent packaging and suggests directions for future research.

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INTRODUCTION

Globally, product counterfeiting has become a rapidly growing industry. As reported by INTA & ICC-BASCAP (2016), the trade in counterfeit and pirated goods has increased significantly, rising from $461 billion in 2013 to a projected $991 billion in 2022. The report states that Asia has emerged not only as the main market but also as the production hub for counterfeit goods, including food sectors, where an estimated 95% of fake food products replace genuine ones, causing severe economic losses and health risks to consumers. This trend is also evident in Indonesia, where the value of counterfeit goods surged from Rp 43.2 trillion in 2010 to a staggering Rp 291 trillion in 2020, alongside substantial tax losses and job reductions (Kontan.co.id, 2023; Mardanugraha et al., 2015). In particular, food and beverage counterfeiting in Indonesia rose from 8.5% of total counterfeit products in 2015 to 20% in 2020, highlighting the growing threat in the domestic food sector (Kontan.co.id, 2023). A striking example is the 2023 counterfeiting of the government-subsidized cooking oil Minyakita, where 1,800 liters of counterfeit oil were packaged to closely resemble the original product and used BPOM registration codes from other legitimate companies, underscoring the alarming vulnerability of Indonesia's food market to fake products (Aminudin, 2024; Putra, 2023).

In light of these challenges, QR code technology has emerged as an effective solution for combating product counterfeiting in Indonesia, particularly because it has already become widely used and accepted among consumers across various sectors (Ariyandi & Handayani, 2022). Given the increasing adoption of QR codes in marketing, payments, and product information sharing, integrating QR code-based verification systems into food packaging provides a familiar and accessible means for consumers to confirm product authenticity (Li et al., 2024; Lydekaityte & Tambo, 2020; Palanisamy et al., 2024). To further enhance security and resilience against counterfeiting, advanced technologies such as the Full Spectrum Color Holographic QR (FSCHQR) system have emerged—representing a major breakthrough in secure labeling by combining multilayer, multicolor QR encoding with high-resolution optical holography (Scholl et al., 2020). Unlike traditional QR-over-hologram approaches, FSCHQR embeds encrypted data directly into each spectral layer (RGB to UV/IR), enabling high-density, tamper-evident, and copy-resistant information storage. Verification can be performed via software or optical elements using a "codebook"-based system. Additionally, modern QR technologies now incorporate spatial-temporal data and AI to detect anomalies during product authentication (Li et al., 2024).

Therefore, in order to ensure the effective implementation of QR codes on packaging as an anti-counterfeiting measure in Indonesia, it is crucial to identify the factors influencing consumers' intention to use such technology. Several previous studies have shed light on key variables that precede consumers' intention to use QR code-based intelligent packaging, such as perceived usefulness and perceived informativeness highlighted by Kim & Woo (2016) and Shin et al. (2012) through adaptations of the Technology Acceptance Model (TAM). Ales (2019) further extended this model by incorporating perceived enjoyment. However, these studies often focused primarily on usefulness and ease of use, potentially overlooking other barriers like perceived fee, technicality, and privacy risk concerns (Li et al., 2024; Palanisamy et al., 2024; Tiekstra et al., 2021; Yang et al., 2024). To address this gap, a more comprehensive approach, such as the Value-Based Adoption Model (VAM) (Kim et al., 2007), is needed to account for these potential inhibitors of adoption. Furthermore, according to Sohn & Kwon (2020), VAM was found to be the best model for predicting behavioral intention toward intelligent products compared to TAM, Theory of Planned Behavior (TPB), and Unified Theory of Acceptance and Use of Technology (UTAUT).

Despite this progress, there remains a paucity of research applying VAM in the Indonesian context, particularly regarding QR code-based intelligent packaging as an anti-counterfeiting measure in the food industry. This research seeks to bridge this gap by using the VAM framework to comprehensively analyze the interplay of perceived usefulness, informativeness, enjoyment, fee, technicality, privacy risk, and perceived value

in shaping Indonesian consumers' intention to adopt QR code-based intelligent packaging for product authenticity verification. By focusing on the unique barriers and motivators in Indonesia's socio-cultural and economic context, this study aims to provide actionable insights for policymakers and industry stakeholders seeking to optimize QR code-based anti-counterfeiting solutions in the food sector.

LITERATURE REVIEW

Based on prior research (Hsu & Lin, 2016; Jingnan et al., 2023; Kim et al., 2007; Kim et al., 2017), perceived usefulness (PU) has been consistently shown to significantly influence perceived value (PV) across various technology adoption contexts, including QR code usage for digital payments (Ashrafi & Easmin, 2023; Musyaffi et al., 2023; Zhong & Moon, 2022). In line with these findings, this study proposes that when consumers perceive QR code-based intelligent packaging as useful for efficiently obtaining information about product authenticity, they are more likely to evaluate the technology as valuable. Hence, we hypothesize that perceived usefulness has a positive effect on perceived value.

H1: Perceived usefulness positively influences perceived value

Perceived enjoyment (PE) has been identified as an important antecedent to the adoption of new technologies (Hsu & Lin, 2016; Kim et al., 2007), including QR code-based intelligent packaging, by measuring the extent to which consumers view the activity of using QR codes as enjoyable and emotionally satisfying (Ricardianto et al., 2023; Ryu & Murdock, 2013; Şentürk, 2024). Consistent with intrinsic motivation theory (Davis et al., 1992; Venkatesh et al., 2002), technologies that provide an enjoyable experience can enhance positive evaluations of their value (Hsu & Lin, 2018; Kim et al., 2007; Mathavan et al., 2024; Rihidima et al., 2022; Yu et al., 2019). In the context of this study, perceived enjoyment refers to the degree to which consumers find using QR codes on packaging to be enjoyable and fulfilling. If consumers perceive this activity as enjoyable, they are more likely to perceive higher value in QR code technology. Thus, we hypothesize that perceived enjoyment positively influences perceived value.

H2: Perceived enjoyment positively influences perceived value

QR codes have been identified as effective tools for providing consumers with detailed product information, including ingredients, authenticity, and certifications (Li et al., 2024; Palanisamy et al., 2024). Especially in Indonesia, halal certification should be clearly displayed on packaging to assure consumers of its sharia compliance (Artadita & Lestari, 2019). This aligns with consumers' growing demand for comprehensive information to support their purchase decisions (Adamashvili et al., 2024). Perceived informativeness refers to how well the information from QR codes meets consumers' needs and expectations (Shin et al., 2012). Previous studies show that perceived informativeness positively affects perceived value (Van-Tien Dao et al., 2014). Therefore, in this study, we propose the following hypothesis:

H3: Perceived informativeness positively influences perceived value

Perceived technicality refers to users' perception of how technically easy and reliable a technology is to use (Kim et al., 2007). Elements such as ease of use, system reliability, response speed, and connectivity shape this perception. In intelligent packaging with QR codes, these elements enhance perceived value by making access to product information quick, smooth, and accurate (Ales, 2019; Kim & Woo, 2016; Ausawanetmanee et al., 2024; Li et al., 2024; Tran et al., 2024; Palanisamy et al., 2024). Prior studies show that when a technology is technically reliable and easy to use, users perceive higher value (Kim et al., 2007; Jingnan et al., 2023; Yu et al., 2019). Therefore, we propose the following hypothesis:

H4: Perceived technicality positively influences perceived value

Perceived fee refers to consumers' perception of the monetary cost associated with using new technology (Kim et al., 2007; Hsu & Lin, 2018). Users typically compare the perceived fee of adopting a new technology with what they have paid for similar products or services before, which

influences their assessment of whether the fee is justified by the benefits they receive (Kim et al., 2007). In the context of intelligent packaging with QR codes, even though the creation of QR codes themselves is relatively inexpensive, additional costs for building and maintaining digital authentication systems can increase product prices and may be passed on to consumers (Li et al., 2024; Palanisamy et al., 2024; Tiekstra et al., 2021). Previous studies have consistently found that perceived fee tends to have a negative impact on perceived value (Kim et al., 2007; Hsu & Lin, 2018; Kim et al., 2017; Mathavan et al., 2024; Sohn & Kwon, 2020). Based on these findings, this study proposes the following hypothesis:

H5: Perceived fee has a negative effect on perceived value

Perceived privacy risk refers to users' concerns about the potential misuse or loss of personal information when interacting with technology (Hsu & Lin, 2018). Previous studies have revealed that perceived privacy risk has a significant negative effect on perceived value in various research contexts (Hsu & Lin, 2018; Jingnan et al., 2023). In the context of QR code usage in product packaging, studies have shown that such concerns can diminish the perceived value of the technology (Palanisamy et al., 2024; Yang et al., 2024). Drawing from these findings, this study posits that as privacy concerns increase, consumers' perceived value of QR code-based intelligent packaging decreases. Thus, we propose:

H6: Perceived privacy risk negatively affects perceived value

In the VAM model, perceived value serves as the key mediator that balances perceived benefits and sacrifices to predict intention to use new technology (Kim et al., 2007; Hsu & Lin, 2018). Consumers who perceive greater benefits relative to their sacrifices are more likely to adopt new technologies. Past research has also established perceived value as a mediator between its antecedents and intention to use (Kim et al., 2007; Hsu & Lin, 2018). Therefore, this study posits that higher perceived value of QR code-based intelligent packaging with product authenticity verification will lead to stronger intention to use. We hypothesize:

H7: Perceived value positively affects intention to use.

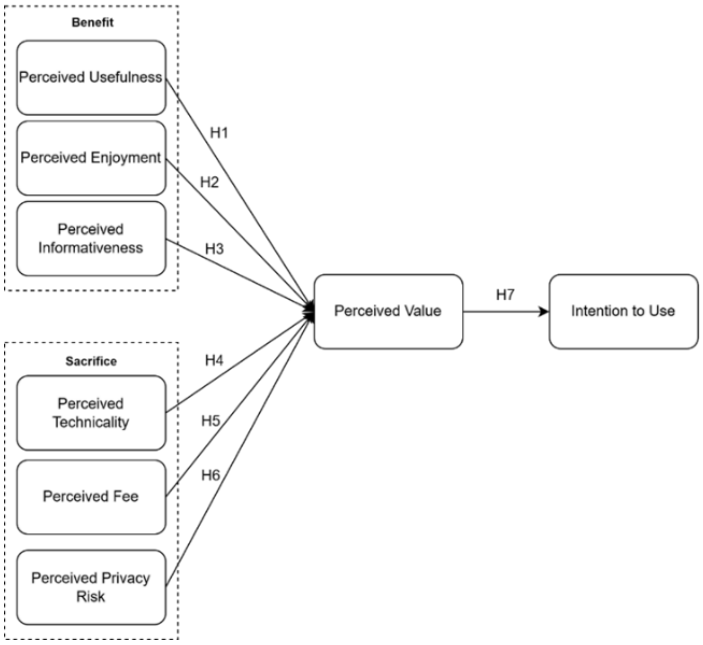

Figure 1. Research Model

Based on the explanations provided earlier, this study examines the effect of antecedent variables on perceived value, and then investigates their consequences on intention to use. The research model is illustrated in Figure 1.

RESEARCH METHOD

This study employed a quantitative approach using a survey design with embedded stimuli, which were validated by a senior software engineer at a technology startup (see Figure 2). According to Hair et al. (2022), the inclusion of stimuli in survey research is permitted as long as the goal is to ensure that respondents have a comparable level of understanding of the object being studied, so that the measurement results can be more valid and fairly compared. The questionnaire was designed using Google Forms, based on a comprehensive literature review and the results of interviews with two experts: a researcher from the National Research and Innovation Agency (BRIN) specializing in intelligent packaging, and a Senior Software Engineer from Grab Singapore who provided technical insights regarding the integration of QR Code-based digital verification systems.

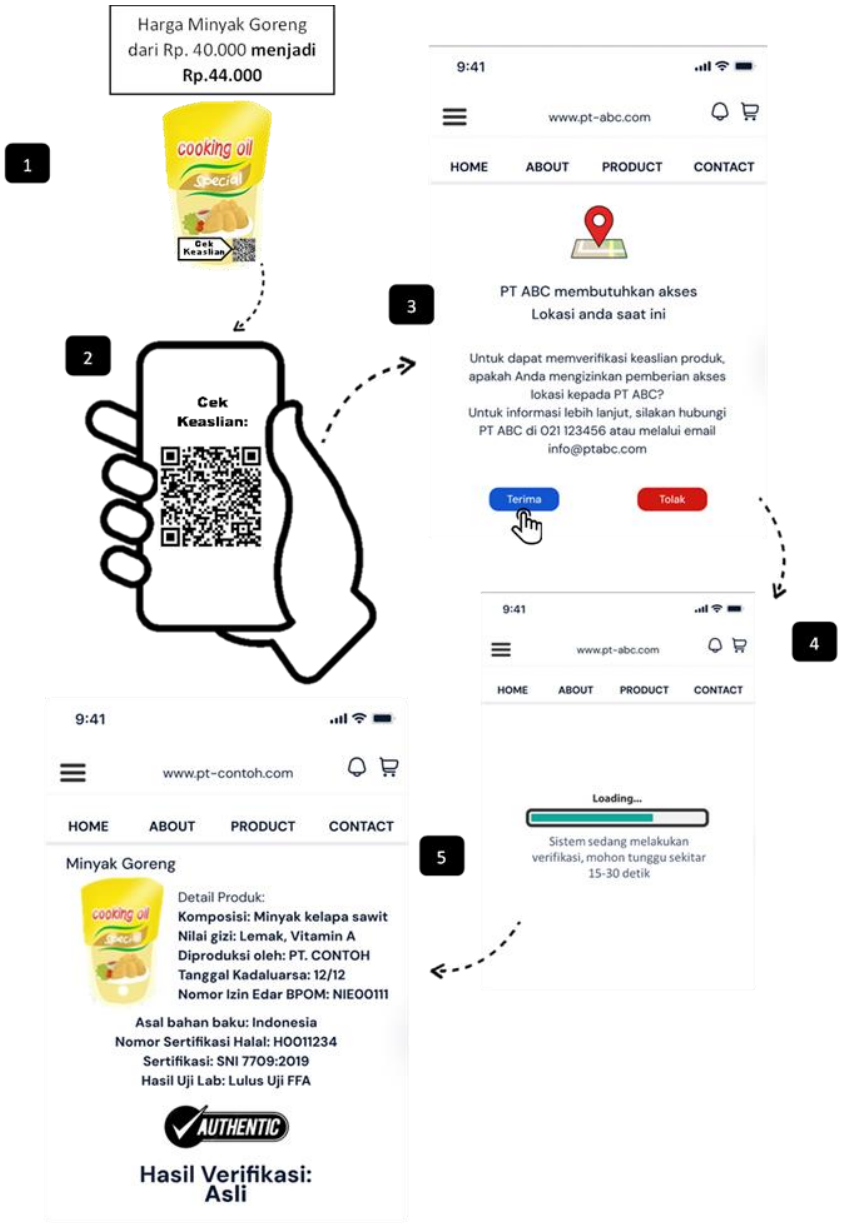

Figure 2. Research Stimuli

The questionnaire consists of three parts. The first part includes screening questions to ensure respondents meet the study criteria, such as whether they have purchased packaged food products in the past three months, the importance of detailed product information on the packaging, the importance of verifying the authenticity of packaged food products, ownership of a smartphone or similar device for scanning QR codes, frequency of QR code usage in daily life, and respondents' consent to participate in the study. The second part presents the main questions with embedded stimulus material and consists of 33 questions that serve as proxies for the research variables. The final version of the measurement constructs is presented in the Table 1.

Table 1. Construct Measurement

Variable	Code	Operationalization of Variables	Indicator Reference
Perceived informativeness	PI.1	The intelligent packaging provides the information I expect.	Tabaeeian et al. (2024)
	PI.2	The intelligent packaging provides detailed information about the product.	
	PI.3	The intelligent packaging provides complete information about the product.	
	PI.4	The intelligent packaging provides information in line with its function.	
	PI.5	The intelligent packaging provides information that helps me in making decisions.	
Perceived usefulness	PU.1	The intelligent packaging allows me to search for product information more efficiently.	Kim et al. (2007)
	PU.2	Using the intelligent packaging enhances the effectiveness of my product information search.	
	PU.3	Using the intelligent packaging makes it easier for me to find product information.	
	PU.4	The intelligent packaging improves the performance of my product information search.	
	PU.5	Using the intelligent packaging is practical.	
	PU.6	The intelligent packaging is useful to me.	
Perceived enjoyment	PE.1	I experience pleasure using the intelligent packaging.	Hsu & Lin (2018)
	PE.2	I feel enjoyable using the intelligent packaging.	
	PE.3	I have fun using the intelligent packaging.	
Perceived technicality	PT.1	I feel it will be easy to use the intelligent packaging.	Kim et al. (2007)
	PT.2	The intelligent packaging will connect instantly after being scanned.	
	PT.3	The intelligent packaging system will take a short time to provide product information to me.	
	PT.4	It is easy to make the intelligent packaging display the product information I want.	
	PT.5	This intelligent packaging system will be reliable.	

Variable	Code	Operationalization of Variables	Indicator Reference
Perceived fee	PF.1	The 10% price increase for the intelligent packaging as illustrated is higher than I expected.	Hsu & Lin (2018)
	PF.2	The 10% price increase for the intelligent packaging as illustrated should not be necessary.	
	PF.3	I am not pleased with the 10% price increase for the intelligent packaging as illustrated.	
Perceived privacy risk	PR 1	There is a privacy risk that I consider when using this intelligent packaging system.	Hsu & Lin (2018)
	PR 2	There is too much uncertainty about privacy security when using this intelligent packaging system.	
	PR 3	My decision to use the intelligent packaging opens up the possibility that my privacy may be at risk.	
	PR 4	Using this intelligent packaging system could lead to a loss of privacy.	
Perceived value	PV.1	The sacrifice/price increase is worth the benefits received when using this intelligent packaging.	Hsu & Lin (2018)
	PV.2	I get more benefits than the effort/risks involved in using the intelligent packaging.	
	PV.3	Using the intelligent packaging is worthwhile for me.	
	PV.4	Overall, using the intelligent packaging gives good value for me.	
Intention to use	IU.1	I intend to use this intelligent packaging when it becomes available in the future.	Hsu & Lin (2018)
	IU.2	I intend to recommend this intelligent packaging to my friends when it becomes available in the future.	
	IU.3	I intend to continue using this intelligent packaging when it becomes available in the future.	

Responses are measured on a five-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree). The third part of the questionnaire is a demographic survey to obtain a general profile of the respondents, including gender, age, education, marital status, average monthly living expenses, average monthly spending on food, frequency of packaged food purchases per month, and how respondents first learned about the use of QR codes on food packaging.

The survey for this research was conducted in May 2025 using a combined purposive and snowball sampling technique. A total of 263 respondents participated in the online survey. However, after applying the initial screening questions to ensure that the respondents met the research objectives and criteria, only 249 respondents were found eligible and included for further analysis using the SmartPLS version 4.1.1.2 software.

The analysis began with a wording test involving five respondents to ensure that every question in the questionnaire was clearly understood. A pretest was then conducted with 30 respondents to evaluate the initial reliability and validity using SPSS version 24. Frequency distribution and descriptive analyses, along with normality distribution testing, were also performed not as a requirement of the method but to ensure that the data characteristics were consistent and supportive of the technical strengths of the PLS SEM approach, making it a suitable method for

further analysis. The results indicated that some constructs were not normally distributed, reinforcing the appropriateness of the PLS SEM technique for this research. Hypothesis testing was conducted using the nonparametric bootstrapping technique with 5000 subsample replications as recommended by Hair et al. (2022) to ensure stable estimates.

RESULT AND DISCUSSION

Demographic data presented in Table 2 show that overall, the sample profile in this study reflects relevant consumer characteristics, is exposed to technology, and represents the dominant age group in everyday packaged food consumption behavior in Indonesia. This provides a strong foundation for generalizing the findings, particularly in evaluating perceptions and intentions to use QR-code-based intelligent packaging.

Table 2. Demographic Data of Respondents

Characteristic	Category	Survey Results	
		Number	Percentage
Gender	Male	117	47%
	Female	132	53%
Age	18-25 years	15	6%
	25 – 34 years	156	62.7%
	35 – 44 years	63	25.3%
	45 – 54 years	12	4.8%
	above 55 years	3	1.2%
Education	Below High School/Equivalent	0	0%
	High School/Equivalent	14	5.6%
	Diploma (D1/D2/D3)	15	6%
	Bachelor's (D4/S1)	150	60.2%
	Master's and Doctorate (S2/S3)	70	28.1%
Marital Status	Single	93	37.3%
	Married, no children	22	8.8%
	Married, with 1 child	76	30.5%
	Married, with 2 children	47	18.9%
	Married, with 3 children	7	2.8%
	Married, with 4 or more children	4	1.6%
Average Monthly Expenditure for Living Expenses (in IDR)	Below 1 million	3	1.2%
	1 - 3 million	16	6.4%
	3 - 5 million	41	16.5%
	5 - 7 million	55	22.1%
	7 - 10 million	63	25.3%
	10 - 15 million	48	19.3%
	15 - 20 million	21	8.4%
	Above 20 million	2	0.8%

Characteristic	Category	Survey Results	
		Number	Percentage
Average Monthly Expenditure for Food Only (in IDR)	Below 500 thousand	4	1.6%
	500 thousand - 1 million	11	4.4%
	1 - 2 million	20	8%
	2 - 3 million	54	21.7%
	3 – 4 million	47	18.9%
	4 - 5 million	64	25.7%
	5 - 10 million	46	18.5%
	Above 10 million	3	1.2%
Frequency of Purchasing Packaged Food Products per Month	Very often (more than 10 times)	88	35.3%
	Often (5 - 10 times)	114	45.8%
	Sometimes (2 - 4 times)	47	18.9%
	Rarely (1 time)	0	0%
	Never	0	0%
Where did you first learn about the use of QR Code on food packaging?	Store/Minimarket/Supermarket	135	54.2%
	Social Media (Instagram, Facebook, TikTok, YouTube, etc.)	87	34.9%
	Friends/Family	15	6%
	Traditional Media (TV, radio, newspaper, billboard, etc.)	12	4.8%
How often do you use technologies such as QR Code in your daily life?	Very Often (more than 10 times a month)	160	64.3%
	Quite Often (5-10 times a month)	64	25.7%
	Sometimes (2-5 times a month)	25	10%

The descriptive analysis presented in Table 3 shows generally positive perceptions of QR code-based intelligent packaging, with high grand means for Perceived Usefulness (4.18), Intention to Use (3.92), Perceived Informativeness (3.99), and Perceived Value (3.80). Lower scores were found for Perceived Fee (2.86) and moderate concerns for Perceived Privacy Risk (3.39). Overall, respondents are receptive to the technology, though price and privacy remain considerations.

Table 3. Descriptive Analysis Result

Variabel	Item	Mean	Median	Min	Max	Std. Dev	Grand Mean
Perceived Informativeness	PI1	4.084	4.000	2.000	5.000	0.784	3.992
	PI2	4.000	4.000	2.000	5.000	0.860	
	PI3	3.992	4.000	1.000	5.000	0.883	
	PI4	3.920	4.000	1.000	5.000	0.893	
	PI5	3.964	4.000	1.000	5.000	0.937	
Perceived Usefulness	PU1	4.104	4.000	1.000	5.000	0.863	4.177
	PU2	4.169	4.000	1.000	5.000	0.833	
	PU3	4.141	4.000	1.000	5.000	0.970	
	PU4	4.277	4.000	1.000	5.000	0.801	
	PU5	4.209	4.000	1.000	5.000	0.834	
	PU6	4.161	4.000	1.000	5.000	0.926	

Variabel	Item	Mean	Median	Min	Max	Std. Dev	Grand Mean
Perceived Enjoyment	PE1	3.996	4.000	1.000	5.000	0.838	3,973
	PE2	3.960	4.000	1.000	5.000	0.877	
	PE3	3.964	4.000	1.000	5.000	0.870	
Perceived Technicality	PT1	3.928	4.000	1.000	5.000	0.987	3,937
	PT2	4.024	4.000	1.000	5.000	0.994	
	PT3	3.988	4.000	1.000	5.000	0.938	
	PT4	4.036	4.000	1.000	5.000	0.933	
	PT5	3.711	4.000	2.000	5.000	1.008	
Perceived Fee	PF1	2.727	3.000	1.000	5.000	1.082	2,863
	PF2	2.747	3.000	1.000	5.000	1.085	
	PF3	3.116	3.000	1.000	5.000	1.060	
Perceived Privacy Risk	PR1	3.538	4.000	1.000	5.000	1.116	3,390
	PR2	3.410	4.000	1.000	5.000	1.141	
	PR3	3.442	4.000	1.000	5.000	1.161	
	PR4	3.169	3.000	1.000	5.000	1.153	
Perceived Value	PV1	3.590	4.000	1.000	5.000	0.970	3.801
	PV2	3.759	4.000	1.000	5.000	0.900	
	PV3	3.876	4.000	1.000	5.000	0.834	
	PV4	3.980	4.000	1.000	5.000	0.804	
Intention to Use	IU1	3.968	4.000	1.000	5.000	0.835	3.915
	IU2	3.900	4.000	1.000	5.000	0.941	
	IU3	3.876	4.000	1.000	5.000	0.912	

The measurement model evaluation (see Table 4) indicates that all constructs meet convergent validity and internal reliability criteria. Most indicators have outer loadings above 0.70, except for one indicator (PT5, Perceived Technicality) with a loading of 0.690, which is retained based on satisfactory AVE (0.731) and composite reliability (rho_c = 0.931, rho_A = 0.913). Other constructs show AVE values above 0.68 and composite reliability ranging from 0.868 to 0.950. Following Hair et al. (2022), indicators with loadings between 0.40 and 0.70 are acceptable if CR ≥ 0.70 and AVE ≥ 0.50. Thus, despite one marginal loading, the constructs are valid and reliable for structural model analysis.

Discriminant validity assessment using cross loadings confirmed that each indicator loaded highest on its intended construct, demonstrating clear empirical distinction among constructs. The HTMT analysis showed that most construct pairs were below the conservative threshold of 0.85, with only two pairs, Perceived Enjoyment and Perceived Usefulness (0.894), and Perceived Value and Intention to Use (0.895), slightly exceeding it. This is theoretically justifiable due to conceptual overlap. Fornell-Larcker criteria further supported discriminant validity as the square roots of AVE for all constructs exceeded their inter-construct correlations. Overall, these complementary analyses indicate adequate discriminant validity, confirming that the measurement model's constructs are empirically distinct and suitable for further structural model analysis.

Multicollinearity assessment using Variance Inflation Factor (VIF) indicated no serious collinearity issues in both the outer and inner models, with most indicators and constructs showing VIF values below the threshold of 5. Although the indicator PR3 in the Perceived Privacy Risk construct slightly exceeded this limit (VIF = 5.259), it was retained due to its strong theoretical relevance, high outer loading (0.936), and the overall model's good fit and reliability. Inner model VIF values ranged from 1.035 to 3.539, confirming that exogenous constructs contribute uniquely without redundancy. These results support the stability and interpretability of the structural model without multicollinearity concerns.

Table 4. Validity and Reliability Measurement Result

Variable	Indicator	Outer Loading	AVE	Cronbach's Alpha	Composite Reliability (rho_a; rho-c)	Interpretation
Perceived Usefulness (PU)	PU1	0.821	0.689	0.910	0.910; 0.930	Valid & Reliable
	PU2	0.857				
	PU3	0.804				
	PU4	0.819				
	PU5	0.861				
	PU6	0.819				
Perceived Enjoyment (PE)	PE1	0.922	0.845	0.908	0.909; 0.942	Valid & Reliable
	PE2	0.908				
	PE3	0.926				
Perceived Informativeness (PI)	PI1	0.845	0.733	0.909	0.914; 0.932	Valid & Reliable
	PI2	0.826				
	PI3	0.869				
	PI4	0.884				
	PI5	0.855				
Perceived Technicality (PT)	PT1	0.872	0.731	0.905	0.913; 0.931	Valid & Reliable
	PT2	0.903				
	PT3	0.897				
	PT4	0.893				
	PT5	0.690				
Perceived Fee (PF)	PF1	0.825	0.687	0.775	0.783; 0.868	Valid & Reliable
	PF2	0.838				
	PF3	0.824				
Perceived Privacy Risk (PR)	PR1	0.865	0.846	0.941	1.044; 0.956	Valid & Reliable
	PR2	0.955				
	PR3	0.936				
	PR4	0.921				
Perceived Value (PV)	PV1	0.832	0.783	0.907	0.911; 0.935	Valid & Reliable
	PV2	0.897				
	PV3	0.913				
	PV4	0.895				
Intention to Use (IU)	IU1	0.923	0.864	0.921	0.922; 0.950	Valid & Reliable
	IU2	0.920				
	IU3	0.946				

The coefficient of determination (R^2) results (see Table 5) show substantial explanatory power for the model, with Perceived Value (PV) at 0.732 and Intention to Use (IU) at 0.674. According to Hair et al. (2022), these values indicate strong predictive accuracy, as 73.2% of PV variance is explained by exogenous variables (PU, PE, PI, PT, PF, PR), and 67.4% of IU variance is explained by PV. These findings confirm the model's robustness in explaining the intention to use intelligent packaging with QR code verification.

Table 5. The Result of R-Square

Variable	R-square	R-Square Adjusted
IU	0.674	0.673
PV	0.732	0.726

Effect size (f^2) analysis (see Table 6) shows that Perceived Informativeness (PI) has a moderate impact on Perceived Value (f^2 = 0.251), while Perceived Technicality (PT), Perceived Fee (PF), and Perceived Usefulness (PU) have small effects. Perceived Enjoyment (PE) and Perceived Privacy Risk (PR) contribute minimally. Notably, Perceived

Value has a large effect (f^2 = 2.072) on Intention to Use, highlighting it as the primary determinant of usage intention in the model.

Table 6. The Result of F-Square

Path Relationship	f^2	Effect Size
PE → PV	0.005	Very Small
PF → PV	0.078	Small
PI → PV	0.251	Medium
PR → PV	0.001	Very Small
PT → PV	0.095	Small
PU → PV	0.042	Small
PV → IU	2.072	Large

The predictive relevance analysis using PLSpredict (see Table 7) demonstrates that the PLS-SEM model exhibits strong predictive accuracy at both indicator and latent variable levels, with all Q^2predict values positive and notably high for key indicators (PV4 = 0.625; IU3 = 0.587) and constructs (PV = 0.714; IU = 0.639). Additionally, Cross-Validated Predictive Ability Tests (CVPAT) show the PLS model significantly outperforms both the Indicator Average baseline and traditional Linear Models in predictive performance, confirming its theoretical validity and practical robustness for accurately forecasting consumer intention to use QR code-based intelligent packaging in the Indonesian food sector.

Table 7. The Result of Q-Square

Item	Q^2predict
IU1	0.538
IU2	0.522
IU3	0.587
PV1	0.521
PV2	0.494
PV3	0.578
PV4	0.625
Variabel	**Q^2predict**
IU	0.639
PV	0.714

The model fit evaluation indicates (see Table 8) that the structural model demonstrates good overall fit, with an SRMR of 0.057 below the recommended threshold of 0.08, and d_ULS (1.801) and d_G (0.866) values within acceptable bootstrap quantile limits, despite d_ULS slightly exceeding the 95% cutoff. The Chi-square value is informative but not decisive due to sample size sensitivity, while the NFI of 0.837 reflects an acceptable fit for exploratory PLS-SEM. Collectively, these fit indices confirm the model's adequacy and suitability for further structural hypothesis testing.

The path coefficient analysis reveals varied strengths of relationships among latent constructs. The strongest effect is from Perceived Value (PV) to Intention to Use (IU) with a coefficient of 0.821, indicating a strong positive influence of perceived value on usage intention. Perceived Informativeness (PI) to PV shows a moderate effect (0.360), highlighting the importance of clear and complete information. Perceived Technicality (PT) and Perceived Usefulness (PU) have modest positive effects on PV, with coefficients of 0.266 and 0.200, respectively.

Table 8. The Result of Model Fit

Fit Index	Saturated Model	Estimated Model
SRMR	0.049	0.057
d_ULS	1.373	1.801
d_ULS Bootstrap	0.822	0.948
d_ULS Bootstrap (95%)	1.058	1.280
d_ULS Bootstrap (99%)	3.872	4.052
d_G	0.830	0.866
d_G Bootstrap	0.663	0.670
d_G Bootstrap (95%)	0.846	0.855
d_G Bootstrap (99%)	1.676	1.685
Chi-square	1193.428	1231.737
NFI	0.842	0.837

Conversely, Perceived Fee (PF) negatively influences PV (-0.161), suggesting higher perceived fee reduce perceived value. Perceived Enjoyment (PE) and Perceived Privacy Risk (PR) exhibit weak effects (0.066 and 0.018), indicating minimal impact on perceived value. These results emphasize the greater relevance of informative and practical factors over emotional or privacy concerns in shaping consumer perceptions of intelligent packaging technology.

The specific indirect effects analysis (see Table 9) highlights Perceived Value (PV) as a key mediator

between exogenous constructs and Intention to Use (IU). The strongest indirect effect is observed in the PI → PV → IU pathway (0.295, modest), emphasizing the critical role of informative content in shaping perceived value and usage intention. Moderate indirect effects are also found for PT → PV → IU (0.219) and PU → PV → IU (0.164), indicating that technical ease and practical benefits enhance intention through perceived value. Conversely, PF → PV → IU shows a modest negative effect (–0.132), suggesting that higher perceived fee reduce perceived value and adoption intention. Indirect effects from PE → PV → IU (0.054) and PR → PV → IU (0.015) are weak, signifying minimal mediation from enjoyment and privacy concerns. Overall, functional and technical factors predominantly drive adoption intentions via perceived value, outweighing emotional and risk perceptions.

Table 9. The Result of Indirect Effect Analysis

Specific Mediation Path	Coefficient (O)	T-Statistic	P-Value	Significant ?	Direction	Strength (Hair et al., 2022)
PE → PV → IU	0.054	1.110	0.267	No	Positive	Weak
PF → PV → IU	–0.132	4.150	0.000	Yes	Negative	Modest
PI → PV → IU	0.295	6.443	0.000	Yes	Positive	Modest
PR → PV → IU	0.015	0.516	0.606	No	Positive	Weak
PT → PV → IU	0.219	4.327	0.000	Yes	Positive	Modest
PU → PV → IU	0.164	2.645	0.008	Yes	Positive	Modest

Out of seven hypotheses tested, five were statistically supported with p-values < 0.05 and expected coefficient directions, while H2 (PE → PV) and H6 (PR → PV) were not supported (see Figure 3). H2 showed a positive but non-significant effect of perceived enjoyment on perceived value (p = 0.266), indicating enjoyment is not a strong factor in shaping perceived value. H6 was both non-significant (p = 0.605) and contrary in direction, suggesting privacy risk is not a major concern for consumers in evaluating packaging value. These results emphasize that functional and technical perceptions dominate perceived value formation over emotional and privacy concerns.

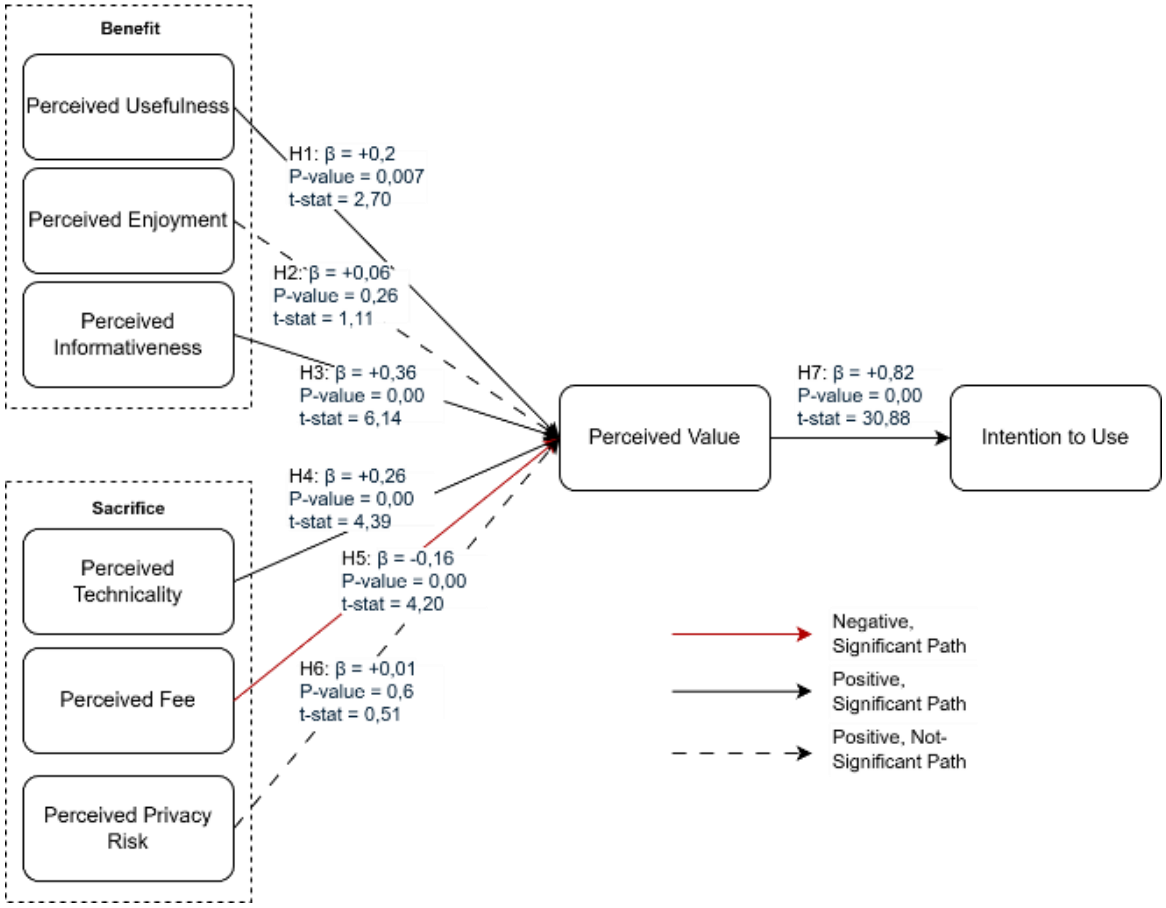

Figure 3. PLS-SEM Analysis Result

The hypothesis testing results indicate that perceived usefulness (PU) has a positive and significant effect on perceived value (PV) with a path coefficient of 0.200 (t = 2.704; p = 0.007), classified as a modest effect. This confirms that the functional benefits of QR code-based intelligent packaging contribute meaningfully, though not dominantly, to consumers' value perception. The finding aligns with previous studies (Hsu & Lin, 2018; Ashrafi & Easmin, 2023) and fits the respondent profile—mostly young, educated, and frequent purchasers—who prioritize efficiency and accurate product information. Thus, PU plays an important role in shaping perceived value, supporting industry efforts to enhance consumer appreciation through practical, user-friendly features.

The hypothesis testing for Perceived Enjoyment (PE) revealed no significant effect on Perceived Value (PV), with a low path coefficient of 0.066 (t = 1.112; p = 0.266), indicating that enjoyment does not meaningfully contribute to consumers' value perception of QR code-based intelligent packaging. This aligns with findings from Jingnan et al. (2023), showing functional rather than emotional factors drive adoption among tech-savvy users. Unlike interactive or immersive technologies (Tabaeean et al., 2024), QR codes are primarily viewed as informational tools for product verification, supported by report from Ricson (2025) and Populix & Statista (2024) showing most consumers scan QR codes for practical information rather than emotional satisfaction. Consequently, the limited hedonic element of QR codes results in weak emotional influence on perceived value, suggesting that adoption strategies should prioritize functional benefits over emotional appeal.

The hypothesis test results show that Perceived Informativeness (PI) has a positive and significant effect on Perceived Value (PV) with a path coefficient of 0.360 (p < 0.001). This finding confirms that the completeness, accuracy, and relevance of information provided by the QR code on intelligent packaging play a crucial role in

shaping consumers' perceived value. The consistency of this result with previous studies (Van-Tien Dao et al., 2014) strengthens the validity of the informativeness-value relationship, especially in the context of product authentication in the food sector. The predominantly productive and highly educated respondent profile supports a preference for information transparency, making perceived informativeness a key factor in enhancing the perceived value of this packaging technology.

The results of hypothesis H4 reveal that perceived technicality (PT) has a positive and significant influence on perceived value (PV) ($\beta = 0.266$, $p < 0.001$). This suggests that the ease of use and reliability of QR Code technology directly enhance consumers' perceived value. Supported by a high grand mean of 3.937 and consistent responses across all technicality indicators, the findings highlight that respondents are familiar with QR Code technology and do not view it as a barrier. Instead, they recognize it as a reliable and efficient system that adds value to intelligent packaging, reinforcing the arguments by Kim et al. (2007) and Venkatesh et al. (2002) that positive technical perceptions, especially in the early adoption stages, are crucial for driving perceived value.

The results of hypothesis H5 reveal a negative and significant impact of perceived fee (PF) on perceived value (PV), with $\beta = -0.161$ and $p < 0.001$. This suggests that higher perceived fee of using QR Code-based intelligent packaging lower the perceived value for consumers, especially in contexts of Indonesian consumers, where price sensitivity is high which significantly influences their decisions (Irawan & Alversia, 2024). While previous studies (Hsu et al., 2018; Jingnan et al., 2023; Mathavan et al., 2024) found no significant effect of fees on value in the long term or in personalized tech contexts, this study aligns with Kim et al. (2007) and Xiong & Zuo (2022), where technologies act as supplements rather than core products. Descriptive data further supports this, showing the lowest grand mean for perceived fee (2.863) and high standard deviation (>1.05), indicating strong price concerns. Consequently, perceived fee's negative effect on value underscores the need for pricing strategies and clearer communication to justify the added cost in daily-use products like edible oil.

The hypothesis testing for H6 indicated that perceived privacy risk (PR) does not have a significant impact on perceived value (PV), as reflected by a coefficient of 0.018 (t-statistic = 0.517, p-value = 0.605). Interestingly, the direction of the relationship was positive, contrary to the initial prediction, but this positive effect cannot be meaningfully interpreted due to its statistical insignificance. Contextually, these findings align with previous research, such as Mathavan et al. (2024) on fitness wearable devices. Their study also found no significant effect of privacy risk on perceived value, indicating a privacy paradox in which consumers prioritize immediate technological benefits over potential privacy threats. In the context of this study, the intelligent packaging system requests location access to verify authenticity, an action that seems normal to many Indonesian consumers who are already familiar with digital apps like ride-hailing or food delivery services. This perception is reinforced by Kominfo & the Katadata Insight Center (2021), which shows that most Indonesians, especially those aged 17–38, tend to be permissive with data access in digital services. Consequently, although privacy concerns are theoretically important, they do not emerge as key barriers to valuing or adopting QR code-based intelligent packaging in daily-use food products. This confirms a more pragmatic and functionality-focused consumer behavior within Indonesia's digital ecosystem.

The results of hypothesis H7 testing demonstrate that perceived value (PV) exerts a strong and significant positive influence on intention to use (IU), with a coefficient of 0.821 (t-statistic = 30.886, $p < 0.001$). This substantial effect size, as per Hair et al. (2022), underscores the critical role of perceived value in driving consumer adoption of QR Code-based intelligent packaging. This finding aligns with the Value-based Adoption Model (VAM), reinforcing the idea that consumers' evaluation of the trade-off between benefits and sacrifices determines their intention to adopt new technologies (Kim et al., 2007; Hsu & Lin, 2018). In this study, consumers recognized the practical benefits of the intelligent packaging, such as ease of accessing reliable product information and verifying authenticity, which aligns with their

existing familiarity and preference for QR Code-based features in daily use. These insights confirm the theoretical predictions of VAM and highlight that perceived value is a decisive factor in the acceptance of intelligent packaging in the food sector.

CONCLUSION

This study concludes that the intention to use QR Code-based intelligent packaging for product authenticity verification in Indonesia is significantly shaped by a combination of cognitive and functional factors that collectively define perceived value. The findings highlight that perceived informativeness, technicality, and usefulness positively and significantly influence perceived value, while perceived fee has a significant negative effect. Perceived enjoyment and privacy risk, however, do not show significant impacts. Notably, perceived value serves as the primary mediator, with perceived informativeness having the largest indirect effect on intention to use. The direct effect of perceived value on intention to use, underscores its pivotal role in driving adoption. Overall, this research provides empirical evidence and a nuanced understanding of how these factors interact and confirms perceived value as the key determinant of consumer intention to adopt QR Code-based intelligent packaging in the food sector.

The findings of this research suggest several managerial implications for stakeholders, including businesses, government, and academia, in fostering the adoption of QR Code-based intelligent packaging for product authenticity in Indonesia's food sector. For businesses, it is critical to prioritize the quality and completeness of product information provided via QR Codes, as perceived informativeness is the strongest driver of intention to use. Clear and relevant information about product origin, safety certifications, and authenticity not only builds trust but also directly enhances perceived value. Additionally, technical aspects such as system responsiveness, ease of use, and reliability should be refined to meet the expectations of tech-savvy consumers, particularly young adults who are accustomed to using QR Codes. Businesses should also address the sensitivity to price increases by leveraging branding and value-based pricing strategies, positioning QR Codes as symbols of product quality and transparency rather than mere cost additions.

Ethically, while perceived privacy risk did not show a significant negative impact on perceived value, businesses must maintain transparency and data protection practices to sustain consumer trust. QR Code systems often involve access to location or personal data, making it essential to communicate data usage policies clearly and ensure explicit user consent. From the government and academic perspectives, campaigns and educational initiatives that promote the use of QR Codes as tools for informed purchasing decisions will strengthen perceived informativeness and foster responsible adoption. Universities and research institutions can further support this by developing user-friendly authentication systems and conducting rigorous usability tests to align with local consumer preferences.

The social implications of this research highlight the role of QR Code-based intelligent packaging as a consumer empowerment tool in the fight against counterfeit and unsafe food products. By delivering clear, easily accessible information and ensuring product authenticity, this technology strengthens consumers' ability to make informed and safe purchasing decisions. Given the high familiarity of consumers with QR Codes and their active engagement in purchasing packaged food, there is strong potential to integrate "scan before consume" behavior into everyday practices. Public education campaigns and community involvement can further reinforce this behavior, turning consumers into proactive participants in food safety monitoring. Thus, intelligent packaging enhances consumer convenience while expanding opportunities for social participation in national food safety efforts, aligning with a vision of transparency and digital literacy in the modern marketplace.

Theoretically, this study extends the Value-based Adoption Model (VAM) to the domain of QR Code-based intelligent packaging for food products, offering new insights beyond its traditional use in digital contexts. It highlights the role of perceived informativeness as the strongest driver of perceived value, while also revealing that

perceived fee remains a crucial deterrent in the food sector. These findings confirm VAM's validity in this new setting and contribute to theoretical understanding of value-based technology adoption in daily life.

Despite its contributions, this study has limitations impacting the social implications of QR Code-based intelligent packaging adoption. The cross-sectional survey captures intentions at a single point, not actual usage behavior, which may be influenced by external factors like technology access or consumer habits. Future longitudinal and experimental studies with diverse demographic samples are needed to better reflect real-world interactions and broader populations, including less digitally literate or rural consumers. Additionally, the findings from Indonesia's unique socio-cultural context, marked by price sensitivity and lower digital privacy awareness, may not generalize globally. This highlights the need for cross-cultural comparisons. Expanding research to other product categories could also reveal varied consumer values and adoption dynamics. This study also has limitations regarding the scope of variables examined; notably, perceived credibility as proposed by Van-Tien Dao et al. (2014) was not included but could be a valuable addition in future research. Incorporating perceived credibility in the context of QR Code-based intelligent packaging may deepen understanding of trust factors influencing consumer adoption, further enriching the model's explanatory power within this technology's usage. Addressing these gaps will strengthen understanding of the social impact and equitable diffusion of intelligent packaging technology.

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