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When do shoppers prefer using QR codes? Empirical evidence from Vietnam

Man The Nguyen^{1,2*} and Tho Alang^{1,2*}

Abstract

This research aimed to explore the factors influencing the behavioural intention to use over-the-counter (OTC) QR codes for purchasing products in Vietnamese supermarkets. The study included 996 consumers and employed a questionnaire-based survey method to test the hypotheses using partial least squares structural equation modelling (PLS-SEM). Drawing on the theory of reasoned action (TRA) and signalling theory, the findings identified five key factors that positively affected the intention to use OTC QR codes: perceived usefulness of OTC QR codes (e.g., for payment and traceability), attitude, customer satisfaction, and supply chain transparency. Additionally, the perceived usefulness of OTC QR codes positively impacted attitude and customer satisfaction, while its usefulness for traceability enhanced supply chain transparency. The study also identified the moderating influence of personal innovativeness on the relationship between perceived usefulness of OTC QR codes for payment and attitude and customer satisfaction. Furthermore, the moderating role of electronic Word-of-Mouth (e-Word-of-Mouth) in the relationship between customer satisfaction, attitude, and behavioural intention was discovered. This research contributes to the existing literature by expanding our understanding of the perceived usefulness of OTC QR codes and elucidating the various mechanisms through which their both functionalities could encourage consumer adoption in the context of Vietnamese supermarkets.

Keywords Behavioural intention, Over-the-counter QR codes, Payment, Traceability, Signalling theory, Theory of reasoned action

Introduction

Due to the increasing reliance of technology-savvy individuals, specifically early adopters, on their smartphones for banking and shopping as well as communication, conventional financial transactions have transitioned to mobile platforms in developing nations. As a result, smartphones have emerged as the most commonly utilized devices for over-the-counter mobile payments.

One notable characteristic of this payment method is that over-the-counter mobile payments are executed electronically via scanning over-the-counter QR codes, thereby eliminating the need for physical payment components [32, 61]. Over-the-counter mobile payments are even thought to be the demise of cash [63]. In addition, the quality of the goods has become an increasingly crucial component in determining whether or not a consumer intends to make a purchase in the present global market. The widespread dissemination of unfavourable events regarding fraudulent and substandard products/items through the media has resulted in a decline in consumer confidence in the products. Additionally, consumers' worries regarding the origin of the products have risen as a result of this dissemination [105]. Nevertheless, as a consequence of the information asymmetry present in the market, the instances of product adulteration

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and substandard goods are not uncommon. Such circumstances can incite a crisis of confidence among the market, ultimately culminating in market failure [80]. Traceability systems are effective instruments for reducing the information asymmetry associated with moral hazard and adverse selection in product systems, and for monitoring product supply chain quality. Hence, the implementation of a traceability system assumes a critical strategic significance in the pursuit of perpetual quality enhancement [93]. QR code (Quick response) technology is progressively being implemented in the manufacturing sector to ensure the traceability of information pertaining to food supply chain [73]. Consumers conveniently utilize QR code labels to acquire critical product supply chain information, including nutritional composition, country of origin, and additional details [78, 99].

Google's analysis indicates that Vietnam, in its transition to a market economy, is experiencing rapid digital economic growth in South-east Asia. In 2022, the growth rate is projected to reach 28%, and in 2023, it is expected to reach 19%. This growth rate is 3.5 times faster than the GDP growth rate.¹ Remarkable gains are obtained via the implementation of cutting-edge technology such as mobile payment and information tracing. For example, the numbers that were released in 2024 by Statista² indicate that China is now in the lead with a penetration rate rating of 37.97% in the "Mobile POS Payments" area of the FinTech industry. Vietnam is in second place with a penetration rate ranking of 29.25%. Italy, on the other hand, finds itself at the bottom of the table with 8.59%, demonstrating a gap of 29.38% points in comparison with China. This illustrates that there is a growing need for people in developing nations like Vietnam to use mobile payments as a means of payment. The QR (Quick response) code, which was formerly employed as a means of accessing information or websites, is now considered to be a key type of contactless mobile payment in Vietnam [71]. It is also a quick and secure manner of payment that customers are becoming more and more used to, particularly in grocery stores and convenience stores [26]. In line with the figures by Yahoo Finance,³ the Global QR Code Payment Market has experienced substantial growth, attaining a valuation of USD 10.28 billion

in 2022. It is projected to continue expanding at a compound annual growth rate (CAGR) of 17.03% through 2028. According to Visa's Consumer Payment Attitudes Study 2023,⁴ 88% of respondents have attempted to use cashless payments. Additionally, 62% of Vietnamese consumers now utilize QR codes for payment, representing a significant increase from 35% in 2021.

Also, in accordance with Vietnamese Prime Minister's Decision 645/QĐ-TTg dated May 15 of the Prime Minister endorsed the national e-commerce development programmes for the period of 2020–2021. A primary objective of the programme is to assist and develop enterprises in utilizing digital technology solutions (e.g., QR code and barcode) for the purpose of verifying the authenticity of products, establishing online brands, and conducting business in the digital environment. Science and Digital Technology (Ministry of Industry and Trade, Department of E-Commerce, and Digital Economy) has developed and implemented a QR code-based system for authenticating products in e-commerce (truyxuat.gov.vn).⁵ By consistently scanning QR codes to access product information and parameters with each transaction, customers are thus effectively pressuring firms to prioritize the provision of clear and high-quality information to meet their needs. Although QR code was introduced to consumers as a tool of payment in Vietnam, consumer experience for multi-functional perspectives of QR codes is increasing at the present time as its use is encouraged due to various reasons (information tracing, QR code mobile payment, etc.)

Recent years have witnessed the implementation of experimental studies on QR codes, according to a review of the pertinent literature. The Technology Acceptance Model (TAM) [45, 101] and Theory of Planned Behaviour [16, 64, 101] served as the main foundation for these studies. However, previous studies primarily concentrated on the single function of QR code rather than on the multi-functional capabilities of this technology for determining the behavioural intention to use QR codes. Consequently, the present study holds considerable importance as it tackles an urgent concern concerning the influence of technology based on multi-functional QR codes (specifically, traceability, and payment) on the

¹ Vietnam News, Vietnam's digital economy is the fastest growing in South-east Asia. Available from <https://www.vietnam.vn/en/kinh-te-so-viet-nam-phat-trien-nhanh-nhat-dong-nam-a-trong-2-nam-lien-tiep/>

² Statista (2024), Penetration rate of mobile POS payments in 34 countries worldwide in 2022. Available from <https://www.statista.com/forecasts/1256541/mobile-pos-payment-penetration-rate-by-country#statisticContainer>

³ Yahoo Finance (2024), Global QR Code Payment Market Outlook 2023-2028: Rising Demand for Convenient and Secure Payment Solutions. Available from <https://finance.yahoo.com/news/global-qr-code-payment-market-164800389.html>

⁴ The Visa Consumer Payment Attitudes Study was prepared by CLEAR M&C Saatchi in October–November 2023, surveyed among 6,550 consumers in Singapore, Philippines, Malaysia, Indonesia, Thailand, Vietnam, and Cambodia. The study conducted interviews with 1,000 Vietnamese consumers across the country who are working part or full time with a demographic mix that sought to create a representative mix of ages (18–65), genders and income levels.

⁵ Industry and Trade Newspaper (2023), traceability by QRCode: Transparency of product quality, protecting consumers' interests. Available from <https://www.vietnam.vn/en/truy-xuat-nguon-goc-bang-qrcode-minh-bach-chat-luong-san-pham-bao-ve-quyen-loi-nguoi-tieu-dung/>.

behavioural intention to use it by consumers in the context of purchasing supermarket's products.

Through the integration of the signalling theory and the theory of reasoned action, this research endeavour will address this deficiency by incorporating supplementary factors including customer satisfaction, attitude, supply chain transparency, and demographic variables. To interpret this theoretical integration, several rationales have been proposed. First, consumers' attitudes towards a behaviour may be positively influenced by QR codes as a signal (e.g., scanning the QR code). If a QR code guarantees a benefit, such as exclusive information, a discount, or essential product information, it may reinforce positive attitudes towards its use [18]. Clear and consistent signalling can improve the efficacy of QR codes. For example, the consistent provision of valuable and pertinent information by QR codes will reinforce positive consumer behaviour [56]. This study also makes a scholarly contribution to the field of traceability by identifying empirical pathways that connect the use of QR codes for traceability to supply chain transparency, and from supply chain transparency to the behavioural intention of using QR codes in purchasing products from supermarkets. Consequently, this research will provide practitioners and businesses with a more comprehensive understanding of the behavioural intention to utilize QR codes when purchasing groceries from supermarkets and develop approaches to expand the product's reach in Vietnam and similar emerging market cases of countries. In addition, knowledge regarding the utilization of moderators for e-Word-of-Mouth and personal innovativeness in the QR code domain remains limited. As a result, we broadened our model by revealing the moderating effect of e-WOM and personal innovativeness to gain additional insights from these integrated frameworks. Briefly, this research examines the following questions: 1. How does the perceived usefulness of QR codes (e.g., both functionalities of payment and traceability) influence supply chain transparency, attitude, customer satisfaction, and behavioural intention? 2. How do supply chain transparency, attitude, and customer satisfaction affect behavioural intention? 3. How is the moderating effect of personal innovativeness on the relationship between the perceived usefulness of QR codes and attitude and customer satisfaction? 4. How is the moderating effect of e-Word-of-Mouth (e-WOM) on the relationship between attitude, customer satisfaction, and behavioural intention?

Theoretical background

The concept of QR code

Among the various auto-ID technologies, QR code technology stands out as one of the most significant advancements. Originally developed to support production lines

in the automotive sector, its application has broadened considerably with the widespread adoption of mobile devices. QR codes are now extensively utilized across diverse commercial fields, including commerce, retail, marketing, logistics, education, tourism, and entertainment [43, 44, 91, 96, 108]. The increasing dependence on smartphones, which consumers carry with them constantly, has driven marketers to continuously devise innovative strategies to enhance customer engagement [13, 86]. QR codes, characterized by their two-dimensional matrix barcodes, can encode various types of data such as plain text, SMS (Short Message Service), and URL (Uniform Resource Locator), while requiring only about one-tenth of the space of a traditional barcode [26].

The adoption of various functional codes significantly enhances the perception of rapid interactions, thereby fostering improved consumer engagement across multiple companies. For instance, a simple scanning method can provide customers with easier access to advertisements, promotions, and other current information related to products or services, thereby fostering a deeper level of engagement. Retailers also benefit from the use of small QR codes to label advertisements on products. This practice allows them to connect with other media or printed platforms at a lower cost while facilitating prompt consumer engagement [4, 53].

QR code payment systems provide businesses with additional avenues to deepen their understanding of the consumer market, extending beyond the realm of advertisements. The streamlined and efficient nature of QR code payments also promotes an increase in transaction volume [32]. Furthermore, the deployment of QR codes in commercial settings, such as on shelves, showcases, posters, and product packaging, is considered as a particularly effective strategy for conveying timely product and brand information to consumers. This effectiveness stems from the QR codes' capability to deliver interactive, targeted, and relevant information precisely when consumers are poised to make a purchase [21].

Theory of reasoned action (TRA)

The theory of reasoned action (TRA), proposed by Ajzen and Fishbein in 1980, was developed to elucidate the model of behavioural intention, emphasizing the pivotal role of an individual's own willingness in determining rational behaviour. According to TRA, subjective norms and attitudes collaboratively shape the intention to engage in a specific behaviour, thereby influencing the decision to perform that behaviour. This study employed the theory of reasoned action to construct a practical model examining the factors influencing food

consumers' use of QR codes when purchasing products from supermarkets.

In recent years, TRA has been widely applied to investigate customers' acceptance of new technologies [104] and has served as the foundation for the development of the technology acceptance model [30]. However, within the context of this study, the concept of attitude was of primary focus, as numerous researchers contend that attitude is crucial for understanding consumer behaviour [98]. Attitude is deemed a critical factor in the success of marketing strategies because human behaviour is often driven by an individual's attitude towards a specific activity [62].

Ajzen [7] posits that general attitudes cannot accurately predict behaviour in specific contexts. Consequently, Chang et al. [25] argue that the theory of reasoned action is particularly suited for predicting and explaining human behaviour in specific contexts. This implies that emphasizing "attitude towards a specific behaviour" is more significant than general attitudes towards a related topic within the framework of the theory of reasoned action.

Signalling theory

According to Connelly et al. [29], signalling theory seeks to elucidate the behaviour of two parties when they have access to disparate information. Zmud et al. [109] proposed that signallers have the advantage of leveraging available information to influence the beliefs and actions of information receivers. Thus, the core focus of signalling theory is on the analysis and application of various types of signalling information [67, 83]. In the context of consumer goods, information asymmetry is a significant issue, highlighting the unequal access to information regarding product quality [84]. To address information asymmetry, primary methods of providing signalling information to potential buyers include the use of logos, labels, and quality illustrations that convey hygiene standards and ingredient details [9]. These methods enable buyers to evaluate and differentiate the reputation and reliability of sellers, ranging from low to high levels [20]. For instance, Mavlanova et al. [67] showed that sellers often refer to the website attributes of online retailers when making purchasing decisions. Despite these efforts, challenges related to information asymmetry between buyers and sellers persist in various markets due to uncertainties in product and seller information [90]. The food market is particularly vulnerable to fraudulent activities, often experiencing scandals that erode consumer trust and pose potential risks to health and well-being [66].

Signalling theory has been applied to the food industry with the integration of blockchain technology [3]. Packaging and nutritional labels on packaged foods serve as

crucial sources of information regarding their nutritional content [70]. These labels provide details such as energy values, protein, fat, carbohydrate, dietary fibre, sodium, vitamins, and minerals, as well as the origin of ingredients and products. The food industry is increasingly prioritizing food quality and safety [51].

This situation can potentially be addressed by enabling the prompt availability of reliable information that can be shared among multiple participants in a network. To evaluate the impact on consumers' attitudes and intentions, it is essential to explore their perceptions of the technology and its implications. Consequently, this study examines whether indicating the use of blockchain-based information can influence consumers' purchase intentions and investigates the moderating roles of word-of-mouth and personal innovativeness in this process.

Research gaps in previous research

There exists a significant gap in the literature concerning the impact of QR codes' multi-functional capabilities (e.g., integrating payment and traceability functions) on consumers' behavioural intentions to use QR codes for making purchase decisions in supermarkets. Previous research has primarily focused on single-function applications of QR codes, such as payment. For example, Hamzah et al. [39] investigate the role of consumer-brand relationships, particularly brand image, as a moderating factor in consumers' continued use of QR code e-wallets in over-the-counter (OTC) retail settings. Utilizing protection motivation theory (PMT), Hamzah [38] examines the psychological concerns of retail merchants regarding the potential transmission of COVID-19 through banknotes, which influences their adoption of QR-based mobile payment (m-payment) services. Similarly, Ramli et al. [76] analyse brand equity components—perceived value, brand image, and brand awareness—to provide a comprehensive understanding of consumers' intentions to use QR code e-wallets (QREW) in the OTC retail environment.

Existing studies typically address the fundamental functionality and applications of QR codes. Despite their widespread usage, there is a paucity of research on the integration of QR codes into critical sectors such as food product supply chains. Treiblmaier and Garaus [90] contend that providing customers with information about the origin and delivery of goods helps reduce information asymmetry and mitigate health risks. This enhanced transparency allows consumers to more effectively evaluate the characteristics of a product. Consequently, exploring the synergistic potential of QR codes could reveal novel research avenues for innovative applications in emerging domains, such as the OTC retail sector within the supermarket industry. Furthermore,

the moderating influence of electronic word-of-mouth (e-WOM) and personal innovativeness on the adoption of QR codes across various sectors, including food supply chains, pharmaceuticals, and entertainment, remains substantially under-investigated [43]. This emphasizes the necessity for scholarly inquiry into these factors as major moderators within the framework of QR code technology adoption.

Hypotheses development

QR code technology, regarded as a facet of blockchain innovation, aims to enhance identity management within the retail industry by facilitating the storage and dissemination of data among relevant stakeholders such as suppliers and customers [22]. This technology has significantly transformed the global goods system [46], enabling parties within the food supply chain to verify the authenticity of information and enhance the efficacy of food recalls [60]. The assurance of traceability and verification within the food supply chain is essential for maintaining clear communication and transparent data sharing at each stage, particularly addressing concerns related to food quality and safety [100].

Chen and Huang [28] emphasize the importance of data transparency within the food industry as fundamental to fostering consumer trust and preventing opportunistic behaviours by producers, thereby bolstering consumer engagement and laying the foundation for their purchasing decisions. This transparency enables brands to build enhanced credibility, encouraging consumers to favour producers who demonstrate greater levels of information disclosure [22]. Consumers tend to prefer producers who offer detailed information about ingredients and processes over those who do not.

Consequently, transparency regarding the food supply chain plays a crucial role in shaping consumer buying behaviours and brand preferences [69]. Drawing on signalling theory, which posits that clear and straightforward communication is beneficial in contexts of uncertainty, we suggest that the adoption of blockchain technology via QR codes acts as a signal of trustworthiness and data security within the supply chain. This signalling mechanism positively influences the quality and safety of products in the market, which, in turn, impacts consumer purchasing intentions. Additionally, conducting transactions via QR code provides users with the ability to track payment details, such as expenditure, product pricing, and account balances. Based on these insights, we propose the following hypothesis:

Hypothesis 1 The perceived usefulness of QR codes for traceability results in the transparency of food supply chain.

According to Kasilingam [50], the perceived usefulness of mobile internet significantly influences individuals' intentions to utilize it. A prominent benefit of QR code payments is their potential to diminish transaction costs, both temporal and monetary. By employing QR code-based payments, consumers can expedite transactions using their mobile devices equipped with cameras, thereby circumventing the need for cash exchanges. Compared to traditional cash transactions, QR code payments facilitate a more fluid and efficient interaction experience, benefiting both the payer and the establishments adopting this method. Additionally, the perceived usefulness of QR codes in tracking information enhances users' ability to acquire and verify precise details about the food product supply chain [19].

McDougall and Levesque [68] highlight the significance of perceived value (usefulness) in cultivating positive consumer attitudes towards products or services. Consequently, the greater the perceived usefulness of QR codes, the more favourable the customer attitude towards adopting this technology. Therefore, this study posits the following hypothesis:

Hypothesis 2a There is a positive relationship between perceived usefulness of QR codes for payment and users' attitude towards it.

Hypothesis 2b There is a positive relationship between perceived usefulness of QR codes for traceability and users' attitude towards it.

Existing literature establishes a connection between the perceived usefulness of a specific technology and customer satisfaction, attributing this relationship to the convenience and functionality offered by technological interactions on smartphones, which can deliver significant value and thus enhance user satisfaction [97]. For example, the research by Amin et al. [12] demonstrated a positive association between perceived usefulness and user satisfaction among mobile users in Malaysia. In a similar vein, Li and Fang [59] posited that the ongoing intent to utilize mobile branded applications is driven by satisfaction and attachment, with the perceived usefulness of these apps acting as a key factor in fostering user satisfaction. In the context of user satisfaction with the functionalities of payment and traceability, this study proposes the following hypothesis:

Hypothesis 3a There is a positive relationship between perceived usefulness of QR codes for payment and users' satisfaction towards it.

Hypothesis 3b There is a positive relationship between perceived usefulness of QR codes for traceability and users' satisfaction towards it.

Several studies have empirically examined the connections between perceived usefulness and behavioural intention. To illustrate, Abdullah et al. [2] discovered the favourable influence of the perceived usefulness of e-portfolios on the intention to use them, while Mailizar et al. [65] uncovered the enabling role of the perceived usefulness of e-learning in shaping the intention to use it. For the association between perceived usefulness and behavioural intention, this study thus put forward:

Hypothesis 4a There is a positive relationship between perceived usefulness of QR codes for payment and behavioural intention to use QR codes.

Hypothesis 4b There is a positive relationship between perceived usefulness of QR codes for traceability and behavioural intention to use QR codes.

Regarding the transparency of the food supply chain, when users utilize a QR code on a food product label to access detailed supply chain information, this action can enhance their trust in the scanning tool [58]. Trust is a crucial determinant of both behavioural intention and actual usage behaviour [34]. Within the realm of blockchain technology, trust arises not merely among participants but from the integrity of the information embedded in the blockchain system, such as a QR code [49]. The decentralized nature and the assured data integrity of blockchain technology foster confidence in transactions among participants who may not have pre-existing relationships, as they can depend on the veracity of the information recorded on the blockchain [34]. Consequently, this study posits that the application of QR codes for traceability on product labels is likely to increase trust in the food supply chain, thereby enhancing behavioural intention to utilize this technology. The hypothesis proposed is as follows:

Hypothesis 5 There is a positive relationship between supply chain transparency and behavioural intention to use QR codes.

Numerous scholarly inquiries have elucidated the relationship between attitude and behavioural intention. For instance, Kasilingam [50] documented a positive influence of attitudes towards smartphone chatbots on the intent to use them. Similarly, Kamble et al. [49] highlighted the critical role of attitudes towards blockchain technology within Indian supply chains, noting that such

attitudes significantly catalyse the intention to adopt this innovative technology. Drawing on these empirical insights, this study constructs the following hypothesis:

Hypothesis 6 There is a positive relationship between users' attitude and behavioural intention to use QR codes.

The academic literature robustly substantiates the premise that customer satisfaction significantly influences positive behavioural intentions, demonstrating a direct and positive correlation between these constructs [40, 81]. This theoretical perspective is further corroborated by findings from several studies [24, 33, 74], which collectively affirm the advantageous effects of customer satisfaction on behavioural intentions. Consequently, informed by this body of evidence, the present study advances the following hypothesis:

Hypothesis 7 There is a positive relationship between users' satisfaction and behavioural intention to use QR codes.

Certain individuals exhibit a natural propensity to embrace new technologies and innovations, while others demonstrate resistance or reluctance towards change [14]. According to Agarwal and Prasad [6], innovativeness is defined as the degree to which an individual is open to new ideas and adopts innovative options before others. Anwar et al. [14] suggest that innovativeness may act as a moderating factor in technology adoption behaviours, implying that individuals with higher innovativeness levels are more likely to adopt innovative services and develop more favourable perceptions than those with lower innovativeness levels. Consequently, innovativeness enhances the readiness to undertake risks associated with adopting new services (e.g., QR codes), with more innovative users being more receptive to such risks, embracing them sooner and thus facilitating their broader adoption. These users are also expected to experience greater perceived satisfaction [79].

Extensive research has acknowledged the moderating role of personal innovativeness in the relationship between perceived usefulness and satisfaction or attitudes towards adopting specific technologies. For instance, Chen [27] found that as the perceived usefulness of Mobile Learning Apps as effective educational tools increased, so did students' satisfaction levels, particularly among those with higher personal innovativeness. In the context of smartwatch adoption, Krey et al. [54] identified through empirical research that personal innovativeness exerts a negative moderating effect on the relationship between perceived usefulness and attitude.

Hypothesis 8a Personal innovativeness moderates the relationship between users' perceived usefulness of QR code (for payment) and satisfaction, such that the higher the personal innovativeness, the stronger the relationship.

Hypothesis 8b Personal innovativeness moderates the relationship between perceived usefulness of QR code (for traceability) and satisfaction, such that the higher the personal innovativeness, the stronger the relationship.

Hypothesis 9a Personal innovativeness moderates the relationship between perceived usefulness of QR code (for payment) and attitude, such that the higher the personal innovativeness, the stronger the relationship.

Hypothesis 9b Personal innovativeness moderates the relationship between perceived usefulness of QR code (for traceability) and attitude, such that the higher the personal innovativeness, the stronger the relationship.

Word-of-mouth (WOM) represents a fundamental form of human interaction that involves the sharing of opinions between two or more individuals regarding various products and services available in the market [94]. Historically, WOM has been recognized as one of the earliest methods for disseminating opinions about marketplace offerings [37], and it remains one of the most effective channels through which consumers exchange information [31]. Electronic word-of-mouth (e-WOM) extends these interactions to the digital domain, involving the discussion of product features and service experiences across various online platforms. Consumers contribute to e-WOM by sharing their direct experiences via media channels such as blogs and social networks, thereby generating reviews and recommendations.

Given the inherent risks associated with purchasing decisions, consumers strive to mitigate these by collecting information from a variety of sources prior to finalizing their purchases [15]. In an online environment, this often involves seeking insights into the quality of products through platforms designed to facilitate the exchange of opinions and information among users [10]. The available information typically includes consumer experiences, found in blogs, social media posts, online evaluations, and recommendations [47]. The credibility of WOM information is enhanced when users engage by reviewing, endorsing, and expressing satisfaction through comments, contributing to its significant influence due to its personal nature [48]. This influence is pivotal in shaping the determination of the intent to utilize online technology for various purposes [106].

In light of e-WOM characteristics, it is often regarded as a moderating variable within structured models. For example, Al Halbusi et al. [11] noted that in environments characterized by positive e-WOM, customers generally report higher satisfaction with online purchases and a stronger intention to continue using a website. Furthermore, when users proactively seek advisory reviews or feedback on social networks, their attitudes towards using specific technologies are more likely to positively influence their behavioural intentions [55, 57]. Therefore, this research formulates the following hypotheses (Fig. 1):

Hypothesis 10 Electronic Word-of-Mouth (e-WOM) moderates the relationship between users' satisfaction and the behavioural intention to use QR codes, such that the higher the e-WOM, the stronger the relationship.

Hypothesis 11 Electronic Word-of-Mouth (e-WOM) moderates the relationship between users' attitude and their behavioural intention to use QR codes, such that the higher the e-WOM, the stronger the relationship.

Research method

Data collection

The primary data for this study were collected using a self-administered questionnaire. Respondents were purposively sampled from various supermarkets in Ho Chi Minh City. In purposive sampling, researchers selectively choose participants who meet specific criteria relevant to the research question or objectives. This method relies on the researcher's judgement rather than random selection, which can introduce bias but is necessary when specific participant types are needed to effectively address the research question [23]. However, a significant limitation of purposive sampling is its limited generalizability due to the selective nature of the sample, which may render the findings less applicable to the broader population, thus constraining the research's overall external validity [5].

To mitigate these limitations, a precise and clear set of criteria for participant selection was established to minimize subjectivity. Eligibility required participants to have familiarity with QR codes, possess online banking or e-wallet capabilities for QR code payments, and own a smartphone capable of scanning QR codes [38, 39, 76]. The survey also assessed whether participants were first-time users of QR codes during their purchasing journey, discontinuing the survey for those without prior QR code experience. Additionally, a detailed methodology description was provided to align with the study objectives.

Further objectivity was ensured by involving other researchers in the selection process to validate the

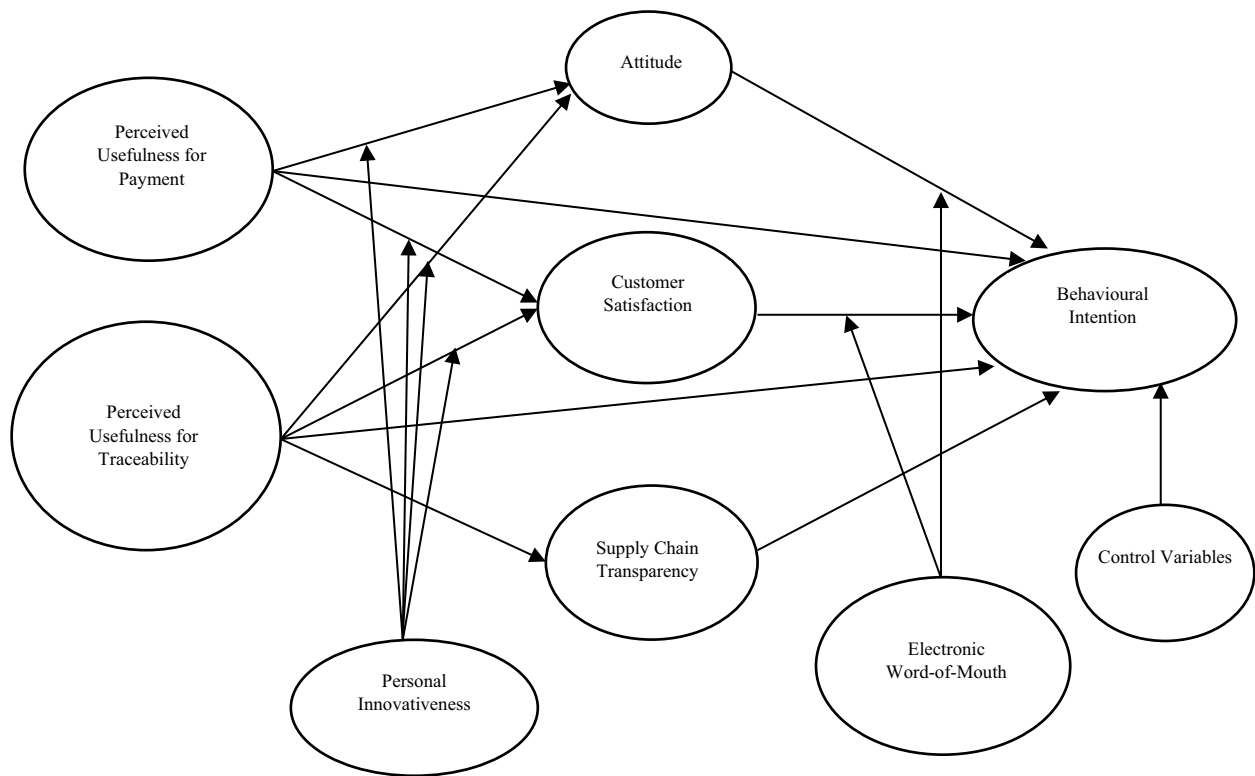


Fig. 1 The research conceptual framework

sample criteria and selections, thereby fostering diverse perspectives. A pilot study involving 125 participants was conducted to assess and refine the sampling criteria and process. Feedback from this pilot was crucial for identifying any overlooked biases and informed adjustments to improve the methodology, particularly in areas concerning supply chain transparency and perceived usefulness for traceability.

Finally, to ensure the reliability of the data collected, research assistants were consulted to review the questionnaire, which was divided into two sections: demographic data collection and the main survey consisting of 32 items across eight constructs. The seven-point Likert scale used ranged from 1 (strongly disagree) to 7 (strongly agree), facilitating an evaluation of consumer acceptance of the studied constructs.

For the research context, Ho Chi Minh City is recognized as a pivotal hub for the adoption of advanced technologies within Vietnam’s economic and social sectors. This makes Ho Chi Minh City an ideal location for sampling purposes. The data collection process employs the supermarket-intercept method, capitalizing on the widespread popularity of supermarkets among the target consumer demographic. Participants were surveyed at the exit points of these retail establishments [82].

The data collection focused on major supermarkets in Ho Chi Minh City, including Winmart, Co. opmart, AEON malls, Top Markets, and Satrafoods, as well as convenience stores such as Circle K, 7-Eleven, Mini Stops, GS25, and Family Mart. The sample included various well-known brands available in these supermarkets and convenience stores, such as Vietnam Dairy Product JSC, Minh Phu Seafood JSC, Acecook Vietnam JSC, Visan Joint Stock Company, Dalat Gap Store, 3Sach Food, Organicfood, and Vietgreen Food.

Between June 2023 and August 2023, data were collected from respondents using a self-administered questionnaire. A total of 1,031 surveys were distributed, with 1,005 completed and returned, yielding a response rate of 97.47%. After the survey period, researchers meticulously screened the questionnaires, excluding those with apparent patterns or excessively short response times. Additionally, nine questionnaires were incomplete and thus deemed invalid. Ultimately, 996 valid questionnaires were retained for analysis, resulting in a recovery rate of 99.10%. Demographic information, including gender, age, education, and monthly income, was also collected and is summarized in Table 1. The gender distribution was balanced, while the age group of 24 to less than 44 years constituted the majority. The largest proportion

Table 1 Background information of participants

	Count	Frequency (%)
Gender		
Male	487	48.9
Female	509	51.10
Age		
Less than 24	233	23.39
From 24 to less than 44	352	35.34
From 44 to less than 64	333	33.43
From 64 above	78	7.84
Education		
Master's degree or above	184	18.47
Bachelor's degree	438	43.97
Undergraduate or less	374	37.56
Income		
Less than 10 million VND	262	26.30
From 10 to less than 20 million VND	229	22.99
From 20 to less than 30 million VND	265	26.60
From 30 million VND above	240	24.11

of respondents held a bachelor's degree, and the monthly income categories were evenly distributed.

Data analysis

The study utilized Smart-PLS 4.0 for data analysis, employing partial least squares (PLS) modelling to validate both structural and measurement models. PLS was chosen for its robustness in addressing residual variances in endogenous constructs and its minimal identification issues [41]. Additionally, PLS is advantageous in consumer research data, which often does not meet the criteria for multivariate normality [42]. Although PLS-SEM and covariance-based structural equation modelling (CB-SEM) are statistically distinct, PLS provides reliable approximations when CB-SEM assumptions, such as normality, are violated. Previous studies have shown that PLS is resilient to issues like omitted variable bias and skewness in regressors [17]. To test for common method bias (CMB), Harman's one-factor analysis was conducted. This test assesses whether the majority of variance is attributable to a single factor. If a single factor explains less than 50% of the variance, CMB is less likely [85]. The analysis revealed that a single factor accounted for 15.88% of the total variance, well below the critical threshold for CMB.

The reliability of the measurement model was evaluated using Cronbach's alpha coefficients, which ranged from 0.70 to 0.91, exceeding the generally accepted threshold of 0.70. Table @@ 4 (in appendix) presents the constructs' reliability, validity, and item loadings, all

of which surpass permissible thresholds, corroborating previous findings. The average variance extracted (AVE) exceeded 0.5, and composite reliability (CR) was greater than 0.7. Table 2 illustrates the correlation between the square root of the AVE and various factors for each construct, with correlation coefficients being less than the square root of each factor's AVE, demonstrating satisfactory discriminant validity. In summary, the measurement model exhibited strong discriminant validity, convergent validity, and reliability.

Results

Table 3 and Fig. 2 display the model coefficients and the model paths along with their significance, respectively. Among the 11 hypotheses, nine receive full support. The findings suggest that the influence of QR codes' perceived usefulness for traceability on supply chain transparency ($\beta=0.077, p\text{-value}<0.05$) and behavioural intention ($\beta=0.123, p\text{-value}<0.001$) is statistically significant, confirming the hypotheses H1 and H4b. Likewise, there is a positive correlation between QR codes' perceived usefulness for traceability and attitude ($\beta=0.084, p\text{-value}<0.05$), as well as customer satisfaction ($\beta=0.068, p\text{-value}<0.05$), providing support for H2b and H3b. In the case of QR code's perceived usefulness for payment, it has a favourable impact on attitude ($\beta=0.079, p\text{-value}<0.05$), behavioural intention ($\beta=0.087, p\text{-value}<0.05$), and customer satisfaction ($\beta=0.081, p\text{-value}<0.01$). Consequently, hypotheses H2a, 4a, and H3a find support.

Regarding other hypothesized connections, attitude exhibits a positive correlation with behavioural intention ($\beta=0.102, p\text{-value}<0.01$), and simultaneously, customer satisfaction is positively linked with behavioural intention ($\beta=0.076, p\text{-value}<0.01$). As a result, this supports and reinforces hypotheses H6 and H7. Moreover, supply chain transparency has a positive impact on behavioural intention ($\beta=0.074, p\text{-value}<0.05$), which results in supporting H5. Regarding the moderation analysis, it is observed that personal innovativeness positively moderates the connections between QR code's perceived usefulness for payment and attitude ($\beta=0.093, p\text{-value}<0.05$) and between QR code's perceived usefulness for payment and customer satisfaction ($\beta=0.070, p\text{-value}<0.05$). Consequently, H9 and H8a are fully supported. Figures 3 and 4 illustrate the enhancing effect of personal innovativeness on the positive slope of the relationships between QR code's perceived usefulness for payment and attitude and between QR code's perceived usefulness for payment and customer satisfaction.

In the same way, electronic Word-of-Mouth (e-WOM) positively moderates the relationships between attitude and behavioural intention ($\beta=0.078, p\text{-value}<0.05$)

Table 2 Discriminant validity and tests of differences between correlations

	ATT	BI	CS	PI	PU-T	PU-P	SCT	E-WOM	Age	Education	Gender	Income
ATT	0.835											
BI	0.146	0.817										
CS	0.079	0.114	0.886									
PI	0.320	0.123	0.257	0.818								
PU-T	0.122	0.182	0.103	0.077	0.823							
PU-P	0.133	0.152	0.126	0.125	0.260	0.881						
SCT	0.023	0.083	-0.006	0.035	0.077	-0.013	0.861					
E-WOM	0.003	0.057	0.019	0.033	0.010	-0.025	-0.053	0.840				
Age	-0.023	-0.021	0.045	-0.022	0.030	-0.010	-0.072	0.019	1.000			
Education	-0.041	-0.038	-0.003	-0.007	-0.008	0.052	0.070	0.033	-0.015	1.000		
Gender	0.072	-0.003	-0.007	0.039	-0.058	-0.054	0.016	0.019	0.066	-0.025	1.000	
Income	-0.003	-0.034	-0.017	0.003	-0.072	-0.039	0.035	0.016	0.018	-0.016	0.016	1.000

Table 3 Structural model estimates

Hypothesis numbering	The hypothesized relationships	Path coefficient	t-Value	S.E	P-value	Decision
Structural model results						
H1	QR code's perceived usefulness for traceability ≥ Transparency	0.077*	2.307	0.033	0.022	Supported
H2a	QR code's perceived usefulness for payment ≥ Attitude	0.079*	2.452	0.032	0.015	Supported
H2b	QR code's perceived usefulness for traceability ≥ Attitude	0.084*	2.400	0.035	0.017	Supported
H3a	QR code's perceived usefulness for payment ≥ Customer Satisfaction	0.081**	2.545	0.032	0.012	Supported
H3b	QR code's perceived usefulness for traceability ≥ Customer Satisfaction	0.068*	2.192	0.031	0.030	Supported
H4a	QR code's perceived usefulness for payment ≥ Behavioural Intention	0.086*	2.497	0.034	0.013	Supported
H4b	QR code's perceived usefulness for traceability ≥ Behavioural Intention	0.123***	4.032	0.031	0.000	Supported
H5	Transparency ≥ Behavioural Intention	0.073*	2.115	0.034	0.036	Supported
H6	Attitude ≥ Behavioural Intention	0.103**	2.918	0.035	0.004	Supported
H7	Customer Satisfaction ≥ Behavioural Intention	0.076*	2.235	0.034	0.026	Supported
H8a	QR – code's perceived usefulness for payment × Personal Innovative-ness ≥ Customer Satisfaction	0.070*	2.166	0.041	0.031	Supported
H8b	QR – code's perceived usefulness for traceability × Personal Innovative-ness ≥ Customer Satisfaction	-0.011	0.353	0.031	0.724	Not Supported
H9a	QR – code's perceived usefulness for payment × Personal Innovative-ness ≥ Attitude	0.093*	2.250	0.041	0.026	Supported
H9b	QR – code's perceived usefulness for traceability × Personal Innovative-ness ≥ Attitude	-0.002	0.057	0.041	0.955	Not supported
H10	e-Word-of-Mouth × Customer Satisfaction ≥ Behavioural Intention	0.082*	2.358	0.035	0.019	Supported
H11	e-Word-of-Mouth × Attitude ≥ Behavioural Intention	0.088*	2.337	0.038	0.020	Supported
The path coefficients of control variables						
	Age ≥ Behavioural Intention	-0.021			0.502	
	Education ≥ behavioural Intention	-0.045			0.159	
	Gender ≥ Behavioural Intention	0.001			0.980	
	Income ≥ Behavioural Intention	-0.025			0.418	

*** ≤ 0.001; ** ≤ 0.01; * ≤ 0.05

and between customer satisfaction and behavioural intention ($\beta=0.081$, p -value < 0.05). This provides additional support for H10 and H11. Likewise, Figs. 5 and 6 both illustrate the augmenting impact of electronic

Word-of-Mouth (e-WOM) on the positive slope of the relationships between attitude and behavioural intention, as well as between customer satisfaction and behavioural intention.

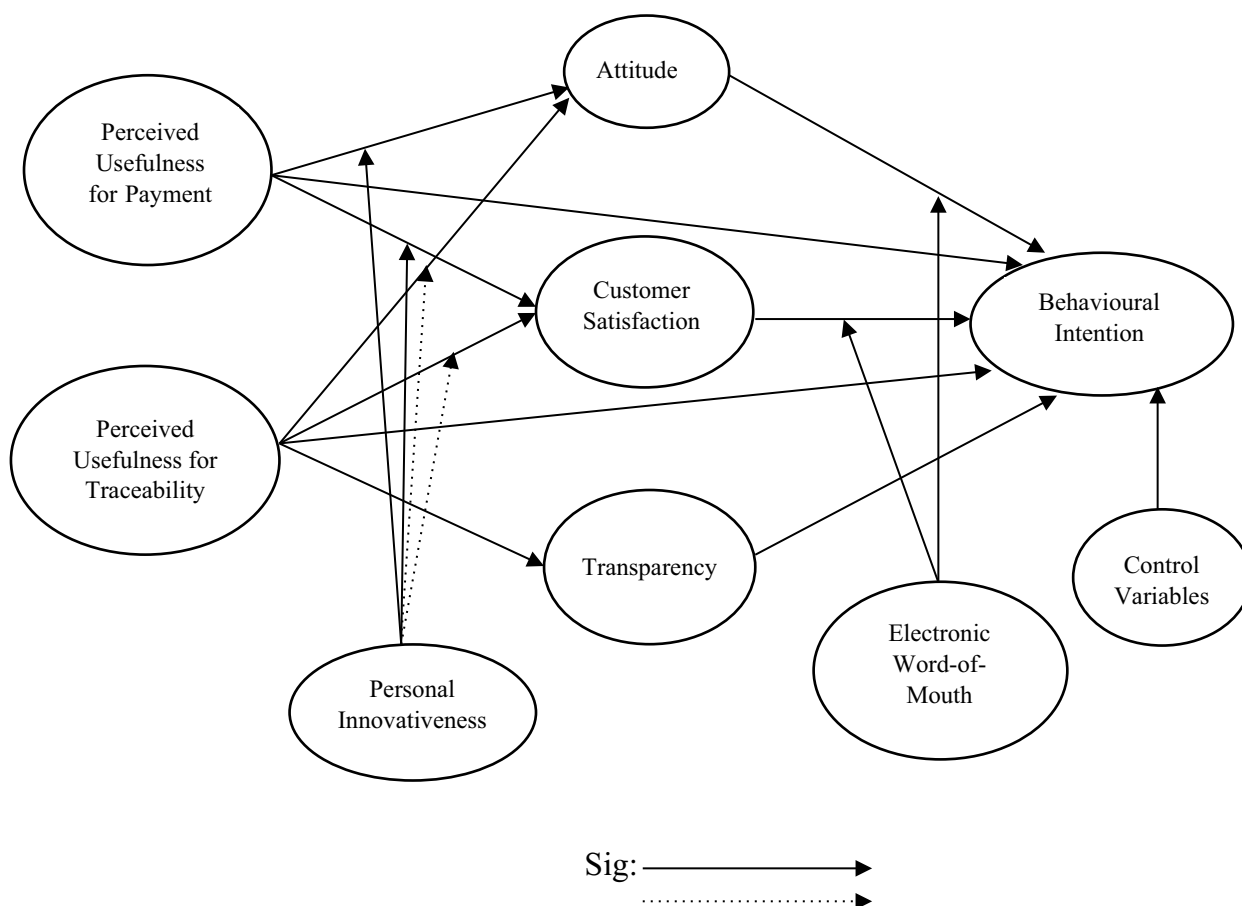


Fig. 2 Model paths

This study does not identify any support for the moderating impact of personal innovativeness on the connection between QR code’s perceived usefulness for traceability and attitude (p -value=0.995) and between QR code’s perceived usefulness for traceability and customer satisfaction (p -value=0.727). Consequently, H8b and H9b are dismissed. Concerning other control factors, this study does not observe any connections between demographic variables and behavioural intention.

Discussion

Implications of findings

The elucidation of the tripartite interrelations among attitude, perceived usefulness of QR codes, and behavioural intention reinforces the theory of reasoned action concerning the connection between attitude and behavioural intention in adoption contexts [8]. The demonstrated pathway from perceived usefulness of QR codes to customer satisfaction, and subsequently to behavioural intention, corroborates the findings of Rezvani et al. [77]. These findings indicate that consumers exhibit higher levels of satisfaction with QR codes and a stronger

intention to use them when they perceive significant value, such as for payment and traceability purposes.

Consequently, the pathway from the perceived usefulness of QR codes to customer satisfaction and attitude, and subsequently to the behavioural intention to use them, is well-supported. Perceived usefulness enhances customer satisfaction and their attitude by improving user experience and meeting customer needs. In turn, higher satisfaction and positive attitudes lead to stronger behavioural intention to use QR codes, driven by positive experience and loyalty.

This study also aimed to identify indicators within the triangular pathway linking QR codes’ perceived usefulness for traceability to supply chain transparency, and subsequently to the behavioural intention to utilize the technology. These findings reinforce the research by Tran and Nguyen [88], which highlights the potential of blockchain technology (including QR codes) to enhance product history visibility within blockchain-enabled supply chain management frameworks. Additionally, these results align with signalling theory, elucidating how QR

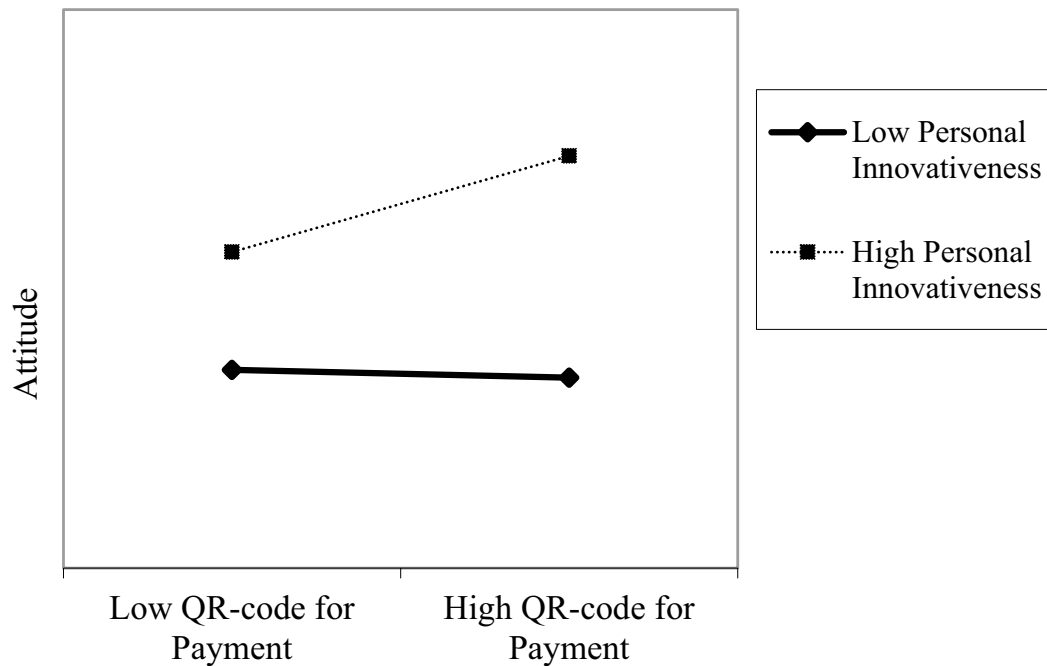


Fig. 3 The moderating effect of personal innovativeness on the relationship between QR code's perceived usefulness for payment and attitude

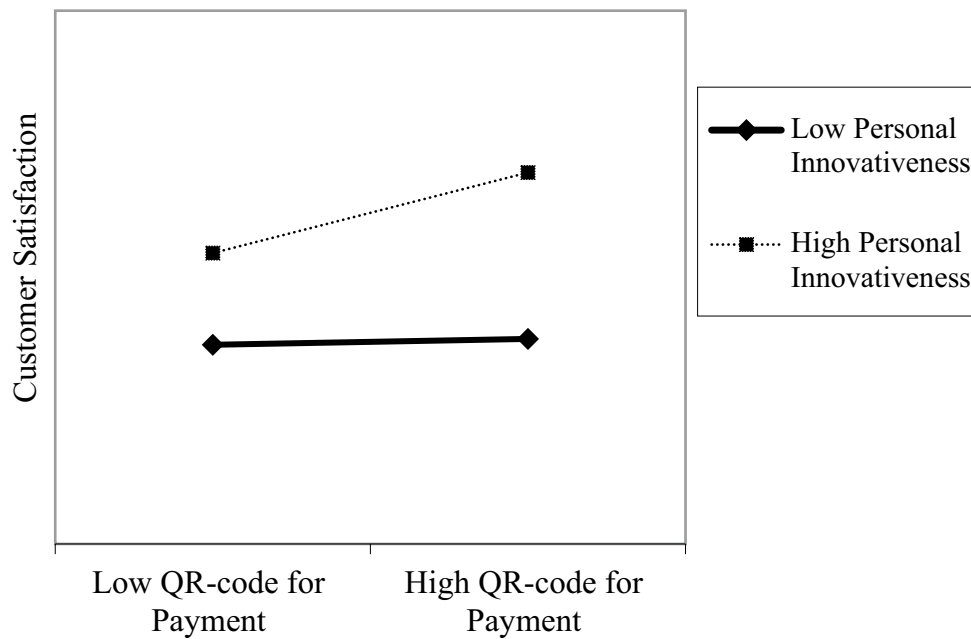


Fig. 4 The moderating effect of personal innovativeness on the relationship between QR code's perceived usefulness for payment and customer satisfaction

code technology aids in mitigating the information asymmetry faced by consumers.

In summary, the perceived usefulness of QR codes for traceability enhances supply chain transparency by providing real-time, accurate, and accessible information

throughout the supply chain. This increased transparency builds trust and confidence among stakeholders, leading to a stronger behavioural intention to use QR codes. By understanding and leveraging this pathway, supply chain managers and organizations can enhance

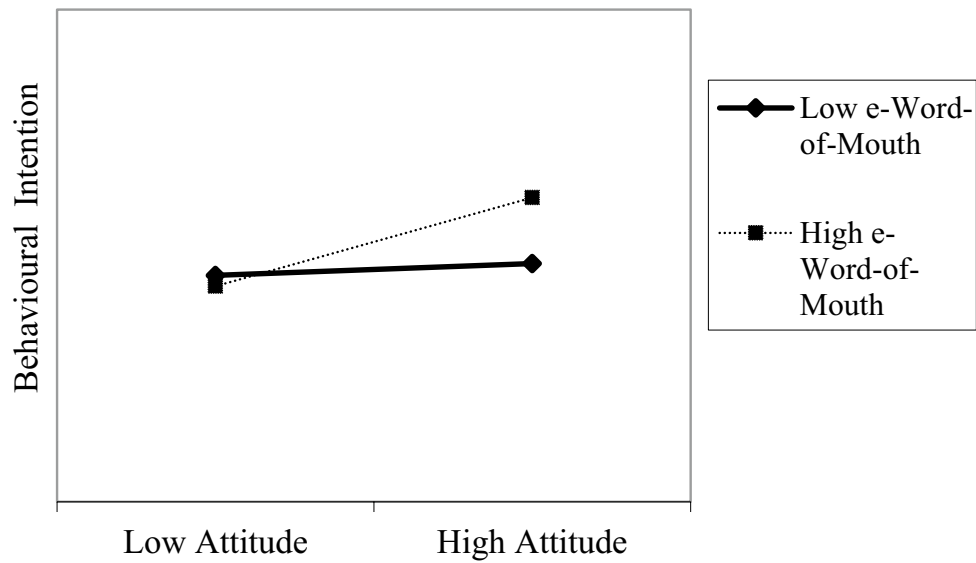


Fig. 5 The moderating effect of e-Word-of-Mouth on the relationship between attitude and behavioural intention

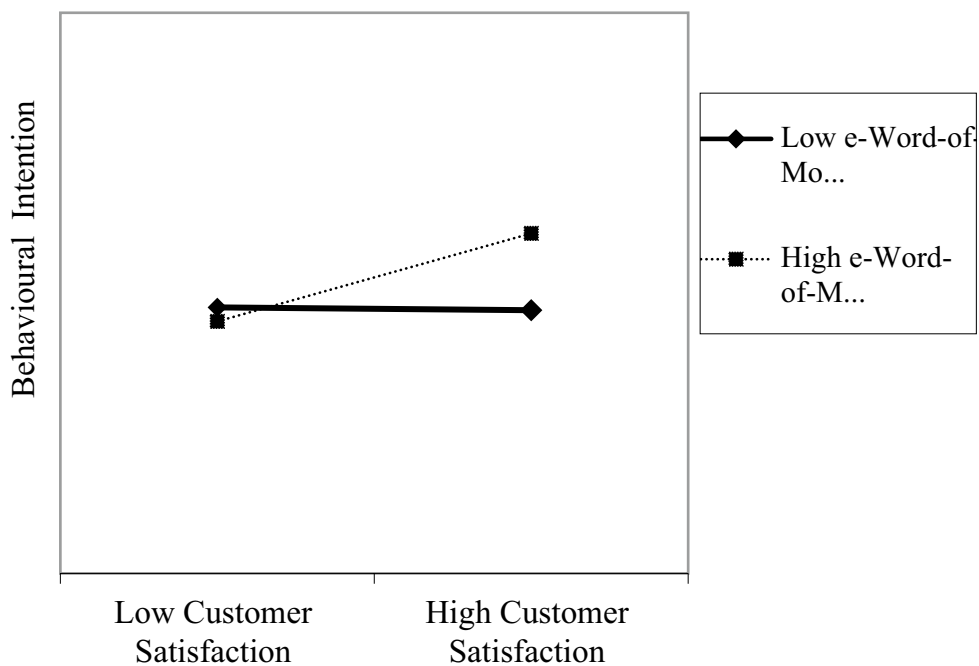


Fig. 6 The moderating effect of e-Word-of-Mouth on the relationship between attitude and behavioural intention

the adoption and effectiveness of QR codes, ultimately leading to more transparent, trustworthy, and efficient supply chain operations.

The results regarding the moderating effect of personal innovativeness (PI) on the relationship between the perceived usefulness of QR codes for payment and consumer satisfaction are consistent with the findings of

Chen [27]. Specifically, consumers with higher levels of personal innovativeness exhibit greater satisfaction with QR codes. These findings support Chen's [27] conclusion that consumers with higher PI are more favourable towards QR codes. In contrast, the results diverge from those of Krey et al. [54], who suggested that more risk-taking and innovative individuals have less favourable

perceptions of the usefulness of applied technology. The current research indicates that forward-thinking and innovative consumers are more likely to perceive QR codes favourably due to their practical benefits.

However, the study did not find similar results regarding the moderating effect of PI for the perceived usefulness of QR codes for traceability. Consequently, there is no significant difference in the perceived usefulness of QR codes for tracing product supply chain information among consumers with varying degrees of personal innovativeness. Such results can be justified by the fact that the tangible advantages of QR codes, such as rapid access to traceability data and the capacity to verify the legitimacy of products, are equally applicable to all users, reducing the significance of personal innovativeness as a moderating factor. Therefore, the differential impact of personal innovativeness is reduced as QR codes become the norm in supply chains, and their value in promoting transparency is recognized universally.

A significant finding is the moderating effect of electronic word-of-mouth (e-WOM) on the relationship between customer satisfaction and behavioural intention, corroborating the observations of Al Halbusi et al. [11]. Similarly, in line with the research of Zamil et al. [102], e-WOM has been shown to moderate the relationship between attitude and behavioural intention. This suggests that consumers with a positive attitude towards QR codes are more inclined to use them, influenced by the advantageous information they obtain through e-WOM. Collectively, e-WOM amplifies the impact of customer satisfaction by providing additional information, social validation, and trust, thereby affecting behavioural intentions. This phenomenon is particularly pertinent in digital marketing and e-commerce, where consumer decisions are significantly shaped by online reviews and recommendations.

Theoretical contributions

By synthesizing the theories of signalling and reasoned action, this study aims to advance the use of QR codes for supermarket purchases. Incorporating insights from Vietnam, it enriches the research on QR codes in developing countries, with findings potentially applicable to other emerging markets. Traceability has received considerable attention in scholarly literature on information systems, supply chain management, and food research. Previous studies have highlighted benefits such as reduced shrinkage and costs and improved efficiency and quality control [35, 75]. However, there is limited research on consumer perspectives regarding traceability systems [90]. This paper addresses this gap by examining the role of QR codes in product supply chain traceability at supermarkets through the lens of signalling theory.

We argue that QR code labels act as external indicators of product quality and origin. This research enhances the literature on the perceived usefulness of QR codes for traceability [22, 100] by explaining how this perceived usefulness leads to supply chain transparency, which in turn affects the behavioural intention to use QR codes for purchases at supermarkets. The integration of fintech, marketing, and supply chain literature provides interdisciplinary insights into QR code technologies and their applications, as suggested by Treiblmaier [89], Treiblmaier, and Garaus [90].

Unlike previous studies focusing on specific QR code functions such as payment [92] or traceability [52], this research is among the first to integrate these functionalities to analyse consumer's use of QR codes in Vietnamese supermarkets. There is limited knowledge about the concurrent application of the theory of reasoned action and signalling theory in examining QR code usage behaviour for these two functions. The theory of reasoned action explains how QR codes enhance perceived usefulness, fostering positive attitudes, and customer satisfaction, which subsequently influences the intention to use QR codes for purchases. Simultaneously, signalling theory demonstrates the perceived usefulness of QR codes in providing product supply chain information, reducing consumer uncertainty about supermarket products. Consequently, this study contributes to the existing literature on QR codes [38, 39, 76] by developing a multi-functional perspective of QR code technology within the over-the-counter retail sector.

Moreover, this study explores the moderating role of e-WOM in QR code technology. It posits that consumer engagement with online guidance strengthens the relationship between attitudes and satisfaction with QR codes and the intention to use them. This research also extends the literature by examining the moderating influence of personal innovativeness in technology adoption, building on the work of Chen [27]. It investigates how personal innovativeness moderates the relationship between the perceived usefulness of QR codes and customer's attitudes and satisfaction.

Overall, this study is a pioneering effort to employ personal innovativeness and e-WOM as moderators in the relationships between the perceived usefulness of QR codes, customer's attitudes, satisfaction, and behavioural intentions. The growing importance of QR code services and the influence of social media highlight the need to investigate these variables and the factors affecting QR code adoption in Vietnam [36, 72, 95]. This research could serve as a foundational model for future studies exploring factors influencing consumer attitudes, satisfaction, and behavioural intentions towards QR code technology in purchasing decisions.

Practical contributions

Firstly, the study's findings demonstrate that the use of QR codes has a positive impact on consumer attitudes and satisfaction, particularly in the context of supply chain information traceability. This effect is especially pronounced for products that provide consumers with reliable recording of supply chain information through QR code technology. QR code labels, which are easily attached to products, have already become common practice in the retail industry. Additionally, QR code-based payments are straightforward for consumers amidst the ongoing digital transformation in the banking and fintech sectors. This form of digital payment, especially when offered in retail supermarkets, enhances customer convenience. Consequently, the implementation of QR code technology requires minimal additional effort from supermarkets and organizations once a technological solution has been established and operationalized. However, realizing the benefits of QR codes depends on proactive communication from companies and banks to educate the public.

Secondly, our findings indicate that QR codes play a significant role in enhancing the transparency of product supply chain information, which in turn motivates consumers to adopt QR code technology for their purchases. This insight is particularly important for companies seeking to transparently communicate their efforts to secure food product supply chains. To establish credibility, companies can provide consumers with access to safety-related product information, thereby enabling active consumer engagement in the supply chain. Companies might also implement policies that specify the extent of consumer awareness regarding existing traceability systems. Furthermore, companies should encourage consumers about the use of QR codes on product packaging to offer detailed information such as ingredients, usage instructions, and nutritional facts, which can build trust and enhance customer satisfaction. Thus, the implementation of QR codes can allow consumers to trace the product's journey from origin to shelf, thereby reinforcing transparency and demonstrating a commitment to quality and ethical sourcing.

Thirdly, supermarkets can leverage QR codes to actively facilitate consumer purchases, particularly for those inclined to explore and assess new technologies and innovations. This approach aids in the rapid formation of new habits and builds trust in products already available in supermarkets. QR code technology shifts the reliability of information from individual entities or organizations to a network of technology and organizations within the supply chain. It can also be employed for digital payment transactions. Organizations can readily capitalize on the diverse possibilities presented by QR code technology to

foster a favourable perception among consumers. This study not only illustrates the benefits of employing QR code technology for traceability and payment in supermarkets but also delineates effective methods for conveying these advantages to consumers. Supermarkets should promote the sharing and exchange of product supply chain information among consumers through the internet, social media, and mobile communication. Facilitating online conversations enables electronic Word-of-Mouth (e-WOM) to disseminate information globally and rapidly.

Fourthly, businesses should also implement interactive marketing strategies, encompassing both promotions and discounts as well as gamification elements. For promotions and discounts, businesses can generate QR codes that direct consumers to exclusive discounts or promotional materials. These codes should be strategically placed on posters, flyers, and social media platforms to drive traffic and stimulate participation. Regarding gamification, companies can integrate QR codes into gamified experiences, such as scavenger hunts or reward-based activities, to enhance engagement and foster brand interaction.

Finally, in a broader context, our research provides essential insights for policymakers and society at large. It is recommended that the government mandates businesses to transparently disclose the data collected through QR codes and its intended use. Furthermore, explicit user consent should be obtained prior to any data collection. Regulators should also enforce that businesses offer clear information regarding the purpose of the QR code, ensuring that users are aware of the outcomes of scanning it. Additionally, the government should conduct regular audits and compliance checks to ensure adherence to QR code regulations, with non-compliance resulting in appropriate penalties or sanctions.

Limitations and future research directions

Like every empirical study, our research possesses specific limitations, emphasizing the need for further comprehensive investigations and replication studies to other contexts to retest our findings in the future. At first, our findings are based on samples that were easily accessible. It is advised that future studies use quota sampling methods to confirm the applicability of our results to various age, economic, and educational categories. Furthermore, integrating purposive sampling with other sampling methodologies, such as random sampling or stratified sampling, can mitigate the selection bias inherent in purposive sampling. This combination allows for a more balanced and representative sample.

Secondly, this research investigated the attitudes of exclusively retail consumers towards QR codes

application for payment and traceability using self-reported data. There is a potential overestimation of their acceptance of this technology. Therefore, subsequent studies should include objective measures, such as the actual usage frequency, to more precisely assess consumer adoption of QR codes for payment and traceability.

Thirdly, this study examined the adoption of QR codes for payment and traceability within the context of an emerging economy characterized by high levels of compliance with government-imposed regulations. Future research could benefit from conducting comparative studies across different countries that adhere to distinct societal and cultural norms. The nuances of national culture could provide valuable insights into how societal behaviours differ across contexts. In Vietnam, the majority of the population complied with the mandatory use of an app called “VNeID,” allowing their personal data to be utilized by the government for identity recognition. This situation stands in stark contrast to that of some individualistic Western countries, where such measures are often perceived as infringements on civil liberties and basic human rights [38].

Fourthly, the integration of QR codes with emerging technologies such as augmented reality (AR), virtual reality (VR), and the Internet of Things (IoT) has been the subject of limited research. Consequently, future studies should focus on the technical challenges and advantages associated with these integrations, as well as potential novel use cases. Furthermore, existing literature frequently neglects the psychological factors influencing scan rates and consumer engagement. Additional research is necessary to comprehend the psychological and behavioural aspects that drive consumer interaction with QR codes. This includes investigating factors such as design, placement, and contextual relevance that impact consumer’s response and marketing effectiveness.

Fifthly, it is imperative for future research to prioritize the development of QR code-based blockchain technology that addresses users’ needs for information and payment. Conducting qualitative research through focus groups could be a productive approach to identify the specific information and payment methods that consumers require to facilitate their purchasing decisions. With

this understanding, user interfaces that effectively convey QR code-based technology can be developed, promoting its implementation in retail supermarkets and enhancing the overall consumer experience. Additionally, future studies should further analyse the influence of internal and external factors, such as privacy, security, trust, government incentives, and e-loyalty, to fully elucidate the driving mechanisms behind consumers’ adoption behaviour of QR code-based technologies.

Conclusion

Drawing on the theory of reasoned action and signaling theory, this research aims to identify the determinants that influence the behavioural intention to use QR codes for purchasing products at Vietnamese supermarkets. Our study reveals that consumer adoption of QR code technology can be significantly predicted by factors such as supply chain transparency, customer satisfaction, perceived usefulness of QR codes (including payment and traceability), and attitudes towards using QR code technology. The results illustrate the pathways from the perceived usefulness of QR codes to supply chain transparency, attitudes, and customer satisfaction, ultimately leading to the behavioural intention to use QR codes. Additionally, personal innovativeness and e-Word-of-Mouth are found to moderate the following relationships: (1) the perceived usefulness of QR codes for payment and customer satisfaction, attitude, and (2) customer satisfaction, attitude, and behavioural intention to use QR codes. This research advances the existing body of knowledge on the behavioural intention to use QR codes. We propose that our analysis has the potential to stimulate further empirical research on QR codes and their impacts within the existing literature. Given the widespread use of QR codes, it is crucial to understand the factors that influence individuals’ intentions to use them and how supermarkets can effectively leverage this technology to achieve their objectives.

Appendix

See Table 4.

Table 4 Measurement model with factor loadings

Item codes	Indicator	Item loadings	Sources
Behavioural intention ($\alpha = .834$; AVE = .668; CR = .837)			Abdul Rabu et al. [1]
BI1	I intend to continue using QR codes for the purchase of goods in the future	0.828	
BI2	I predict that I would use QR codes for the purchase of goods in the future	0.795	
BI3	I plan to continue using QR codes for the purchase of goods in the future	0.819	
BI4	I intend to recommend other consumers to use QR codes for the purchase of goods	0.826	
Perceived Usefulness for Payment ($\alpha = .905$; AVE = .777; CR = .912)			Türker et al. [92]
PU-P1	QR code mobile payment services are a useful mode of payment	0.875	
PU-P2	Using QR code mobile payment services makes the handling of payments easier	0.882	
PU-P3	QR code mobile payment services allow for a faster usage of mobile applications	0.889	
PU-P4	By using QR code mobile payment services, my choices as a consumer are improved (e.g., flexibility, speed)	0.878	
Perceived usefulness for traceability ($\alpha = .841$; AVE = .677; CR = .844)			Ausawanetmanee et al. [16]
PU-T1	Using QR code traceability system for the purchase of goods improves the way I receive information about the origins of the goods	0.822	
PU-T2	I find the QR code traceability system for purchasing the supermarkets' goods to be useful	0.842	
PU-T3	Using the QR code traceability system enables me to learn about the supermarkets' product information	0.800	
PU-T4	I find the QR code traceability system for the purchase of supermarkets' goods to be advantageous, and the sellers should adopt this system to serve customers	0.828	
Supply chain transparency ($\alpha = .886$; AVE = .742; CR = .917)			Zelbst et al. [103]
SCT1	The related information from QR code is available to me to view	0.831	
SCT2	The information from QR code allows me to easily discover the specific materials used to make our products and where those materials are produced	0.884	
SCT3	The information from QR code allows me to easily discover from where materials used in our products originate	0.880	
SCT4	The information from QR code proves that the materials used to produce the products are responsibly and sustainably sourced or produced	0.849	
Personal innovativeness ($\alpha = .835$; AVE = .742; CR = .917)			Anwar et al. [14]
PI1	Among your friends, you are usually the first to try out QR codes technology	0.820	
PI2	If you heard about QR codes technology, you would look for ways to experience it	0.804	
PI3	You like to experiment with QR codes technology	0.827	
PI4	You would consider trying out QR codes technology, even if you hadn't heard of it yet	0.820	
Attitude ($\alpha = .855$; AVE = .697; CR = .855)			Abdul Rabu et al. [1]
ATT1	It is a good idea to use QR codes for the purchase of goods	0.831	
ATT2	It is beneficial to use QR codes for the purchase of goods	0.834	
ATT3	It is interesting to use QR codes for the purchase of goods	0.846	
ATT4	I have positive feelings towards using QR codes for the purchase of goods	0.827	
Customer satisfaction ($\alpha = .909$; AVE = .786; CR = .909)			Zhao et al. [107]
CS1	I feel satisfied at my recent experience with using QR codes	0.878	
CS2	QR codes exactly provides what I need at my recent experience	0.889	
CS3	I have good experience at my recent experience with using QR codes	0.886	
CS4	I am satisfied with my decision to use QR codes in a recent transaction	0.893	
Electronic word-of-mouth ($\alpha = .864$; AVE = .706; CR = .899)			Sun et al. [87]
eWoM1	I seek information about QR code from both the Internet and social media from the people	0.871	
eWoM2	I believe the Internet and social media are the easiest ways to get information about QR codes	0.855	
eWoM3	I believe that others have spoken of QR codes to me	0.809	

Table 4 (continued)

Item codes	Indicator	Item loadings	Sources
eWoM4	I believe that the information about QR codes on social network sites is more important to me	0.824	

Abbreviations

E-WOM	Electric word-of-mouth
QR codes	Quick response codes
TRA	Theory of reasoned action
ATT	Attitude
CS	Customer satisfaction
BI	Behavioural intention
PI	Personal innovativeness
SCT	Supply chain transparency
PU-T	QR code's perceived usefulness for traceability
PU-P	QR code's perceived usefulness for payment
AVE	Average variance extract
α	Cronbach's alpha
CR	Cronbach reliability

Acknowledgements

Not applicable.

Author contributions

MTN developed and identified the research gap, designed the research methodology, did the analysis, and wrote the paper. AT did the analysis and wrote the paper. All authors read and approved the final manuscript.

Funding

This research was conducted independently and self-funded by the authors. No external funding or financial support was received for the completion of this research.

Availability of data and materials

Data will be made available on reasonable request.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that we have no competing interests.

Received: 3 May 2024 Accepted: 27 August 2024

Published online: 06 September 2024

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