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Biometrics Authentication for E-payment: An Empirical Approach to Understanding user Adoption

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Abstract: *This study is designed to assess several key predictors of user intention to accept biometrics authentication for e-payment. To do so, a research model is constructed based on the prominent unified theory of acceptance and use of technology (UTAUT) framework. Further, the UTAUT model is expanded by integrating three prevalent constructs that are essential to accept biometrics authentication. As the principal analytical tools, structural equation modelling (SEM) and importance performance map analysis (IPMA) are employed. The study reveals significant effects of performance expectancy, effort expectancy, social influence, perceived risk and perceived trust on attitude. Moreover, attitude, facilitating conditions, and perceived trust play a substantial role in predicting user adoption intention to biometrics authentication in e-payment. The IPMA suggests that perceived trust and facilitating conditions fall into the critical zone, requiring special managerial considerations. This research has offered a comprehensive research model to explore users' biometrics authentication adoption behaviour, particularly in the field of e-payment. This study assesses the initial adoption behaviour of biometrics authentication in e-payments; therefore, assessing users' continuance usage behaviour of this technology can be a potential for future research.*

Keywords: *biometrics authentication; electronic payment; technology adoption; SEM; IPMA*

1. Introduction

Tremendous advancement in financial technology has brought a new paradigm in the domain of electronic payment (e-payment). E-payment can be defined as the use of digital technologies for the payments of goods and services (Ogbanufe & Kim, 2018). In the context of e-payment, a key issue is the identification or authentication process for completing payment transactions. Identification refers to the establishment of someone's identity, answering the question "who this person is?", while authentication aims to confirm someone's identity, answering the question "is this person the one he claims to be?"

Traditionally, authentication for e-payment was password-based or token-based, which suffered mainly from their security measures (Ogbanufe & Kim, 2018). Fraudsters often target conventional e-payment systems to steal consumers' valuable resources (i.e., sensitive information and financial resources) (Miltgen et

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al., 2013). Managing passwords is very difficult, and the token can easily be stolen.To face this challenge, e-payment service providers need to ensure an improved security system, as traditional methods cannot ensure the originality of the presence of the presenter of a password or token (Yang et al., 2013). Therefore, experts suggested biometrics as an alternative to conventional authentication systems for e-payment (Clodfelter, 2010), which is considered a safe, secure and convenient mechanism, particularly in the field of electronic payment (e-payment) systems.

Biometrics authentication provides significant benefits, such as increasing safe and secure transactions, reducing the risk of identity theft, enabling faster payments, and ensuring convenient payments. However, this technology has experienced various challenges toward its wider acceptance among consumers, as customers perceive the potential risks associated with the widespread adoption of this technology (Miltgen et al., 2013). Customers are very concerned about security and privacy issues (two vital components of perceived risk) of their sensitive information, which inhibits the acceptance of biometrics authentication, particularly in the e-payment context (Angst & Agarwal, 2009).

As the use of biometrics authentication in the context of payment is a relatively new phenomenon, empirical research on this issue is still at the nascent stage. The author observed a few related pieces of literature and divided them into three groups: (i) scientific studies focusing mainly on the design or feasibility of biometric technologies in the sense of payment (Yang et al., 2013), (ii) descriptive studies stating the meaning, categories, advantages and challenges of implementing biometrics authentication (Kumar & Ryu, 2009), and (iii) empirical studies investigating the determinants of biometrics authentication adoption (Ogbanufe & Kim, 2018). Most of the extant research on user adoption of biometrics authentication for payments is exploratory, which fails to measure the predictors of biometrics authentication adoption in e-payment.

Hence, this investigation has been designed to assess the subsequent research inquiries. (i) Which variables are crucial in the adoption of biometric authentication for electronic payments? Furthermore, what are the pivotal elements that require enhancement in order to promote the usage of biometrics authentication? In this study, the popular structural equation modelling (SEM) is employed. In addition, the author has augmented the SEM methodology by using the importance-performance map analysis (IPMA). The IPMA helps decision-makers recognize the critical factors that receive low concentration despite their high importance scores. The employment of the SEM-IPMA method may offer a shift in the methodological paradigm in the technology adoption research, which offers an innovative and comprehensive understanding of biometrics adoption in e-payment.

2. Literature Review and Model Development

2.1 Biometrics authentication

Biometric authentication is the process of using various physical or behavioural traits to verify and confirm a person's identification (Ogbanufe & Kim, 2018). Although biometric technology was accepted sporadically by customers in the past, in recent years, the application of this technology has experienced a steady increase (Miltgen et al., 2013).

Biometrics in the e-payment authentication system provides users with a reliable, convenient, secure, and cost-effective payment facilities (Stylios et al., 2022). According to a China's Payment and Clearing Association (CPCA) survey, nearly 95% of the interviewees declared that they "knew about" fingerprint recognition. Also, 70% of users said they were comfortable with biometrics authentication for making payments in 2016. This large number denotes that an increasing number of users diagnose the necessity of a user-friendly and secure biometric authentication system for e-payments. Yang et al. (2013) and Kumar & Ryu (2009) provided an explanation of the definition, various varieties, potential advantages, and difficulties associated with payments based on biometric authentication. Bilgihan et al., (2009) examined the factors that influence customers' acceptance of fingerprint technology for payments and concluded that perceived risk, personal innovativeness, and convenience play a key role in the adoption of fingerprint payment technology.

A major concern of adopting biometrics authentication is the privacy and security associated with that system. According to Kumar & Ryu (2009), biometrics systems have much more complex security measures compared to other information systems. While no biometric technology can offer absolute security, experts emphasize that high-cost systems such as iris scanners possess greater accuracy in making identifications compared to low-cost technologies like signature dynamics (Srivastava, 2009). Since there is a wide variety of biometrics technologies available to recognize the person, correctly or erroneously and with or without an individual's permission, biometrics authentication systems can threaten the total system's privacy and security (Hadzidedic et al., 2022).

2.2 Research model development

Within the realm of information systems research, two established theories are the theory of reasoned action (TRA) (Ajzen & Fishbein, 1980) and the theory of planned behaviour (TPB) (Ajzen, 1991), which are employed to evaluate an individual's behaviour towards the adoption of technology. These two theories claim that the primary determinants of the intention to adopt technology are the individual's attitude, which is shaped by their behavioural beliefs, and subjective norms, which are influenced by their normative beliefs.

Drawing on the TRA and the TPB, Davis (1989) subsequently developed the Technology Acceptance Model (TAM). Despite its widespread acceptance in the literature, the TAM has faced several criticisms. Firstly, it provides only general information about users' perceptions of innovations. Secondly, it places too much emphasis on a deterministic approach, disregarding individual characteristics. Lastly, it assumes that the use of technology is entirely voluntary. Rogers (2010) established innovation diffusion theory (IDT) in the IS literature, which has been validated as a solid framework for comprehending the spread of technology in both organizational and individual contexts. Nevertheless, IDT predominantly

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focuses on technological aspects while disregarding other individual, organizational, and societal issues. Another widely used paradigm is the technology-organizational-environmental (TOE) framework, which was introduced by Tornatzky et al. in 1990. Nevertheless, this framework is more appropriate for the context of organizations rather than individuals.

Corresponding to the limitations of past information technology (IT) adoption models, a widespread technology adoption model is the UTAUT constructed by Venkatesh et al. (2003) on the basis of a thorough analysis of eight popular IT adoption models. This model has been applied extensively in the extant research that seeks to assess the technology adoption behaviour. The UTAUT consists of four primary constructs: performance expectancy, effort expectancy, social influence, and facilitating conditions. This integrated model has the capability to account for approximately 70% of the variability in user behaviour (Talukder et al., 2019).

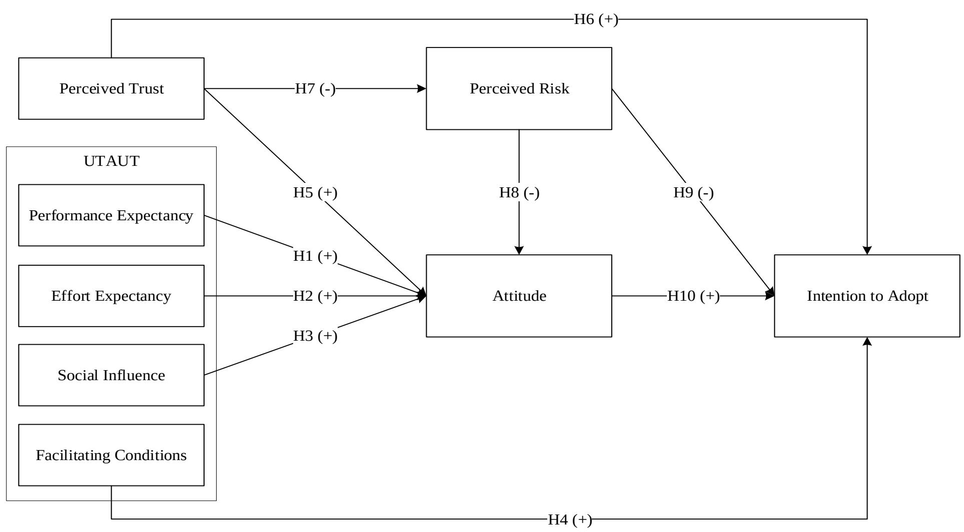

Figure 1. Research framework

The physiognomies of biometrics authentication (e.g., accessibility, security, trust, convenience) are connected to several determinants of organizational, individual, and technological characteristics. Hence, the author applies the UTAUT as the foundation of the research model for investigating biometrics authentication-enabled e-payment adoption. In addition, the author extends the UTAUT model by attitude, perceived trust, and perceived risk. Extending existing models with relevant contextual variables has gained tremendous popularity in modern research (Khayer & Bao, 2019). The author implants attitude as a mediator since the degree to which biometrics-enabled e-payment is useful, convenient, and simple can affect the consumers' attitude, and behavioural intention typically relies on attitude. The presence of risks in users'

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minds is a major inhibitor for accepting biometrics authentication, particularly in the e-payment context. Perceived trust also plays a positive role in diminishing perceived risk and motivating users towards accepting biometrics authentication for e-payment (Zhou, 2014). The study framework with appropriate hypotheses is depicted in Figure 1.

3. Hypotheses Development

3.1 Performance expectancy (PE)

When a person believes that the use of a technology will enhance the performance of achieving a task is known as performance expectancy. Within the realm of electronic payment systems, consumers typically prioritise precise, secure, convenient, and expeditious financial transactions. Ogbanufe & Kim (2018) did a comparison analysis of standard authentication methods and biometric authentication methods in the context of electronic payment systems and stated that biometrics authentication provides two types of benefits such as pre-transaction benefits (e.g., reduction in cognitive effort and enhanced convenience) and after-transaction benefits (e.g., deception reduction, quick transaction, and easy payment). In another study, Liébana-Cabanillas et al., (2023) revealed that performance expectancy is the most significant predictor of intention to adopt biometric mobile payment. Considering the various benefits offered by biometrics authentication in e-payment, this study assumes that consumers expect that the use of biometrics authentication may assist them in achieving financial transactions more quickly and increase productivity and flexibility in payments, which will lead to forming positive attitudes. Thus,

H1: Performance expectancy positively affects attitude toward biometrics authentication for e-payment.

3.2 Effort expectancy (EE)

The extent of ease of use associated with s technology is known as effort expectancy. Research in the field of Information Systems has established that the perception of ease of use significantly influences the development of a favourable attitude towards adopting new technology (Talukder et al., 2019). Contemporary biometrics systems are user-friendly and have the potential to enhance convenience for customers while conducting financial transactions Morosan (2011). According to Ogbanufe & Kim (2018), perceived convenience refers to the simplicity and ease of use offered by the payment method. The role of effort expectation is crucial in the use of a security-based system due to its potential time-saving benefits. The cognitive work of a consumer is diminished when they are not required to recall the accurate username and password for every transaction. Consumers can enjoy convenience and flexibility during payment, checkout, and travel, which is a key force to adopt biometrics (Ogbanufe & Kim, 2018). Biometrics authentication in e-payment is an easy-to-use and convenient system that may require little knowledge and effort, which influences consumers' attitudes positively. Thus, the author formulates the subsequent hypothesis.

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H2: Effort expectancy positively affects attitude toward biometrics authentication for e-payment.

3.3 Social influence (SI)

A person's perception can be changed by the views, opinions, and suggestions given by another person or group of persons. In China, the use of communication interfaces among the young generation is more subject to social influences (Bao et al., 2017). Transferred to the domain of biometrics authentication in e-payment, social influence could be a major determinant of user attitude. Modern people think that technological invasion into one's personal life is normal; therefore, social influence fosters acceptance of biometrics technology (Liu et al., 2019). However, in line with several prior studies, this study considers that social circles perceive biometrics technology as normal, and influences from social circles such as family, friends, and colleagues positively affect an individual's attitude towards a socially acceptable system like biometrics authentication for e-payment.

H3: Social influence positively affects attitude towards biometrics authentication for e-payment.

3.4 Facilitating conditions (FC)

Venkatesh et al. (2003) specified that the perception regarding the presence of organizational and technical enabling conditions would motivate the acceptance of a technology. The IS literature has proven a favourable correlation between enabling situations and adoption intention (Bhuasiri et al., 2016), when a strong relationship was found between facilitating conditions and biometric mobile payment adoption (Liébana-Cabanillas et al., 2023). For biometrics authentication for e-payment, facilitating conditions include enabling conditions that will support individuals to accept the system. Facilitating conditions include having the necessary infrastructure, providing practical instruction to use the system, 24/7 help desk facilities, compatibility with other systems, and delivering quick responses to queries. More extraordinary facilitating conditions will create more positive intentions to adopt biometrics authentication. Thus,

H4: The presence of facilitating conditions has a positive impact on the intention to employ biometrics authentication for e-payment.

3.5 Perceived Trust (PTR)

The importance of trust is emphasized in the electronic payment environment (Sulaiman & Almunawar, 2021), as there is a longitudinal and chronological distance between payer and payee, whereby payers need to provide personal information to others (Ogbanufe & Kim, 2018), The less transparency and poor control over personal data given during transactions could cause trust problems (Liebana-Cabanillas et al., 2017). Since trust has been critical in the domain of IS, researchers have extensively addressed trust from various viewpoints. In the context of biometrics authentication in e-payment, trust is even more critical as there is a possibility of being hacked off the sensitive consumers' financial and biometrics information. Hence, consumers frequently feel more uncertain about

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e-payment service providers and the consequences of online transactions (Slade et al., 2015). In terms of biometrics authentication for making e-payments, consumers need to provide their biometrics data to the service providers. Thus, if service providers fail to develop a trustworthy environment involved with the biometrics authentication-enabled e-payment, consumers will not be motivated towards its adoption. This research assumes that an upper level of trust in the biometrics authentication for e-payment will positively impact consumers' attitudes and further, affect consumers' intention to adopt biometrics authentication for e-payment. Thus,

H5: Perceived trust significantly influences attitude toward biometrics authentication for e-payment.

H6: Perceived trust significantly influences the adoption of biometrics authentication for e-payment.

Furthermore, by creating a positive perception regarding the system use, trust reduces perceived risk and helps overcome the uncertainty of the behaviour (Slade et al., 2015). The negative impact of trust on perceived risk is supported by several research pieces conducted in different technology contexts (Johnson et al., 2018). Being consistent with the above studies, the author conceptualizes that perceived trust negatively influences an individual's perceived risk of accepting biometrics authentication. Thus,

H7: Perceived trust negatively affects perceived risk.

3.5 Perceived risk (PR)

The perceptions of risk significantly influence consumers' adoption behaviour directly and indirectly through influencing attitudes. For example, any technology's adoption decision is affected by perceived risk, particularly when consumers perceive that the adoption of that technology will generate feelings of uncertainty, discomfort, anxiety, conflict, psychological discomfort, or cognitive dissonance (Shin, 2010). Wu and Wang (2005) claimed that the percentage of mobile commerce purchasing goods is negatively connected to the perceived risk involved in online purchasing. Bauer et al., (2005) argued that perceived risk is a significant inhibitor in mobile marketing adoption. In the e-payment context, risk perceptions play a more severe role in accepting emerging technology-enabled payment systems like biometrics payment. Extant literature extensively emphasizes the significance of assessing perceived risk (Liu et al., 2019). Chen (2013) conducted a study that evaluated the influence of perceived risk and discovered that users' perception of risk had a notable adverse impact on both their attitude and intention to embrace mobile banking services in the context of Taiwan. Within the realm of biometrics payment, individuals express concern regarding the potential compromise of security and privacy when engaging in online transactions. Therefore, the author establishes the following hypotheses.

H8: Perceived risk negatively influences user attitude toward biometrics authentication.

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H9: Perceived risk negatively affects the adoption of biometrics authentication for e-payment.

3.6 Attitude (AT)

Attitude and subjective norms collectively determine the likelihood of the person taking a specific action (Venkatesh et al., 2003). Extant literature on IS confirmed attitude as a strong predictor of adopting and using innovative technology (Angst & Agarwal, 2009; Shin, 2010). Extant literature revealed a favourable connection between attitude and adoption intention. For instance, Liébana-Cabanillas et al. (2014) revealed that attitude is an essential predictor of behavioural intention in the mobile payment context. Morosan (2011) conducted research investigating the determinants of biometrics authentication in restaurants and identified that attitudes act as a strong determinant of behavioural intention. Thus, this study posits that attitude has a favourable impact on predicting user intention to adopt biometrics authentication for e-payment.

H10: Attitude positively affects behavioural intention in adopting biometrics authentication for e-payment.

4. Methodology

4.1 Questionnaire formation

A close-ended questionnaire was created, which was segmented into two parts. Part A contained 32 questions about the various latent constructs of the model. In Appendix A, the corresponding measurement objects of each construct are given. The measuring instruments have been adapted from existing literature with minimum context-specific modifications to enhance the authenticity of the material. Two researchers proficient in technology adoption research conducted an initial pre-test of the questionnaire parts to enhance transparency, correctness, and comprehensibility. In order to collect data, the author employed a five-point Likert scale. Part B consisted of the demographic characteristics of the responder.

4.2 Data Collection

Before administering the survey, a pilot test was done to assess the effectiveness of the questionnaire with a sample of 40 from Huazhong University of Science and Technology, Wuhan, P.R. China. The results of the exploratory factor analysis indicate that each measurement item exhibits a strong loading on its respective construct (>0.70), which recommends that the scale fulfils the validity criteria. This study targets Chinese adults as the population. As there is no appropriate sampling frame, the author has applied a non-probabilistic convenience sampling. The author has collected data by conducting a cross-sectional survey at different important locations (e.g., shopping centres, supermarkets, and university campuses) in Wuhan, P. R. China. To avoid response bias, the author instructed respondents to exclude their names, living addresses, identification numbers, and contact information. The author distributed 350 questionnaires; among them, 309 were received. Due to incomplete responses, 24 questionnaires were rejected. Appendix B depicts the demographic physiognomies of respondents.

4.3 Common method bias test (CMB)

In order to deal with the issue of CMB, the author has employed both procedural methods and statistical testing (Schwarz et al., 2017). As a procedural step, the identity of the responders was kept confidential. In addition, participants were encouraged to make unambiguous responses. The selection of the words was meticulously made to reduce the level of opacity. Furthermore, alongside the procedural measurements, certain statistical tests were conducted. The author assessed CMB using Harman's single-factor technique (Harman, 1976). Principal component factor analysis and varimax rotation were used to evaluate the dataset and determine the number of variables needed to explain variation. The test results notified that a single variable explained 40.42% of the variation, less than the required 50%. In addition, Table 2 shows how variance inflation factors (VIF) were used to detect CMB. Since these values were below 3.3 (Kock, 2015), the author may conclude that this study is CMB-free.

4.4 Data Analysis

The author has used the SEM approach to analyze the hypotheses, assess the predictive significance of the model, and interpret the validity and reliability of the components. The ability of the PLS-SEM technique to test several relationships at once made it the most suitable method. The relationship between each construct can only be examined separately using other traditional statistical techniques such as multivariate variance analysis (Hair Jr. et al., 2016). Additionally, when assessing a theoretical model, PLS-confirmatory SEM's approach supersedes other multivariate approaches. Additionally, the author has supplemented the SEM methodology by using the IPMA. SmartPLS version 4 was used to run the dataset.

5. Results

5.1 Measurement model

The measurement model is judged by testing internal reliability, convergent validity and discriminant validity. The constructs' internal reliability was checked by employing various criteria such as Cronbach's Alpha, rho (ρA), and composite reliability metrics. In order to assess internal reliability, it is necessary for the reliability parameters of each variable to be equal to or more than 0.70 (Henseler et al., 2014; Henseler et al., 2009). Items reliability was checked by their loading values. The values for the reliability criteria, as displayed in Table 1, satisfied the suitable range, hence guaranteeing the constructions' elevated internal reliability. The author evaluated the convergent validity using factors such as average variance derived (AVE) and item loading. In order to ensure the consistency of convergent validity, it is recommended that the values of AVE and loadings exceed 0.50, as suggested by (Fornell & Larcker, 1981). According to the data provided in Table 1, the AVE and loadings values were below the required threshold.

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Table 1. Measurement model

Constructs	Loadings range	Cronbach's Alpha	rho_A	CR	AVE
Attitude	0.864-0.916	0.858	0.861	0.914	0.779
Behavioural Intention	0.860-0.901	0.855	0.855	0.912	0.776
Effort Expectancy	0.841-0.858	0.804	0.805	0.884	0.718
Facilitating Conditions	0.742-0.889	0.762	0.818	0.861	0.677
Performance Expectancy	0.799-0.855	0.860	0.861	0.905	0.705
Perceived Risk	0.866-0.892	0.903	0.907	0.932	0.773
Perceived Trust	0.720-0.818	0.801	0.800	0.870	0.627
Social Influence	0.749-0.813	0.799	0.803	0.868	0.622

Source: Developed by the author

Table 2. Discriminant validity and VIF

	Correlation Matrix and Square Root of the AVE								VIF		
Constructs	**AT**	**BI**	**EE**	**FC**	**PE**	**PR**	**PTR**	**SI**	**AT**	**BI**	**PR**
AT	**0.883**									1.236	
BI	0.657	**0.881**									
EE	0.656	0.627	**0.848**						1.863		
FC	0.437	0.495	0.433	**0.823**						1.235	
PE	0.694	0.665	0.616	0.459	**0.840**				2.046		
PR	0.518	0.315	0.322	0.197	0.370	**0.879**			1.292		
PTR	0.652	0.582	0.582	0.431	0.572	0.441	**0.792**		2.515		1.000
SI	0.682	0.546	0.570	0.381	0.641	0.429	0.741	**0.789**	2.693		

Source: Developed by the author

Further, the author assessed the discriminant validity by evaluating the consistency of the Fornell-Larcker and Heterotrait-Monotrait Ratio (HTMT) parameters. All the square roots of the AVE values (as shown in Table 2) exceeded the respective coefficients of correlation, thereby satisfying the Fornell-Larcker recommendations. Furthermore, all HTMT ratio values (as shown in Table 3) were less than 0.90, which confirms sufficient discriminant validity for all constructs (Henseler et al., 2014).

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Table 3. Heterotrait-Monotrait Ratio (HTMT)

Constructs	AT	BI	EE	FC	PE	PR	PTR	SI
AT								
BI	0.764							
EE	0.788	0.755						
FC	0.526	0.595	0.525					
PE	0.805	0.775	0.738	0.545				
PR	0.586	0.357	0.374	0.251	0.414			
PTR	0.776	0.696	0.719	0.535	0.678	0.512		
SI	0.804	0.645	0.703	0.458	0.762	0.497	0.835	

Source: Developed by the author

5.2 Structural model

The key estimation of the structural model's goodness is R^2 and the degree of significance of the path coefficient. As this research model has the ability to explain 66.5% of the variability in attitude, 51.2% of the variability in intention to employ biometric payment, and 19.4% of the variability in perceived risk, it can be said that the model is statistically validated. The path significance level was assessed by employing the bootstrapping method with 5000 re-samples. Table 4 depicts the consequences of the hypotheses test.

Table 4. Structural model

Hypotheses	Paths	Coefficient (β)	*t*- statistics	Decision
H1	PE -> AT	0.282	4.929	Accepted
H2	EE -> AT	0.238	4.174	Accepted
H3	SI -> AT	0.184	3.161	Accepted
H4	FC -> BI	0.214	4.604	Accepted
H5	PTR -> AT	0.127	2.267	Accepted
H6	PTR -> BI	0.223	3.579	Accepted
H7	PTR -> PR	-0.441	8.421	Accepted
H8	PR -> AT	-0.203	4.191	Accepted
H9	PR -> BI	-0.057	1.185	Rejected
H10	AT -> BI	0.448	7.185	Accepted

Source: Developed by the author

The analysis revealed that all hypotheses, with the exception of H9, were statistically confirmed. It can be seen from the table that performance expectancy, effort expectancy, social influence, and perceived trust positively influence attitude. On the other hand, perceived risk has a negative influence on user

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attitude. Moreover, the presence of facilitating conditions, perceived trust, and attitude significantly influence the intention to accept biometrics authentication. This study further validates that there is a strong negative effect of perceived trust on perceived risk.

5.3 Importance-performance map analysis (IPMA)

In this analysis, by using the SmartPLS 4 version program, the author ran IPMA in SEM two times. Attitude and behavioural intention were selected as the target constructs. The author created two priority maps based on the importance and performance ratings, as shown in Figure 2 and Figure 3. Figure 2 shows that perceived trust, effort expectancy, and perceived risk have lower performance scores despite their higher importance in explaining attitude. Therefore, managers should focus more on these constructs in order to improve user attitudes toward biometrics authentication in e-payments. However, performance expectancy is a well-managed variable as it has both relatively higher importance and performance compared to other variables. Figure 3 indicates that facilitating conditions and perceived trust are low-performing variables despite their relatively higher importance compared to perceived risk. Hence, managers need to allocate more resources to developing facilitating conditions and trust to boost the adoption of biometrics authentication in e-payments. Finally, it is clear from Figure 3 that attitude is an effective and well-managed predictor of behavioural intention to adopt biometrics in authentication in the e-payment context.

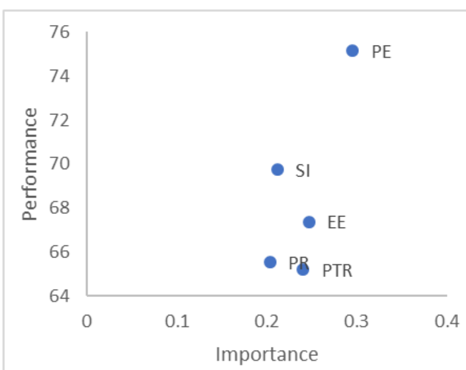

Figure 2: IPMA for attitude

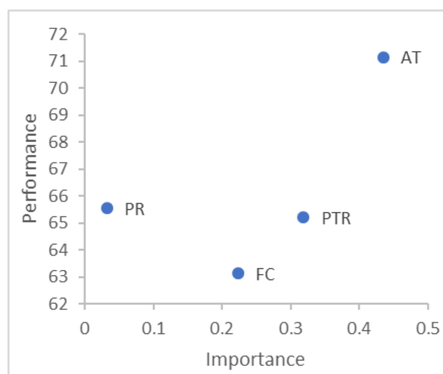

Figure 3: IPMA for behavioral intention

6. Discussion

One of the essential motivators for forming a positive attitude toward biometrics authentication for e-payment is effort expectancy. Individuals believe that biometrics authentication requires minimum time and effort compared to other old-fashioned authentication methods for e-payments, which motivates them to form a positive attitude toward this emerging technology. Also, performance expectancy was identified to have an influential role in forming a positive attitude toward the acceptance of biometrics authentication. This means that a

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user's attitude can be evaluated based on the degree to which it demonstrates usefulness and benefits to the users. Multiple previous studies on technology adoption have corroborated similar conclusions (Johnson et al., 2018; Oliveira et al., 2016; Slade et al., 2015). Social influence played a noteworthy role in influencing consumers' attitudes toward accepting biometrics authentication for e-payment. Consistent with the findings of (Liebana-Cabanillas et al., 2017), this study examines the impact of several reference groups, such as family members, friends, and peer groups, on consumers' attitudes, especially in voluntary situations.

This study found perceived trust as a vital factor that has direct effects on both consumers' attitudes and behavioural intentions to adopt biometrics authentication. This discovery aligns with previous research that demonstrated trust as a fundamental requirement for users to embrace electronic services (Adjei, 2015; Hampshire, 2017; Liebana-Cabanillas et al., 2017; Shin, 2010). This result is expected as Chinese people have trust in the adoption of any innovative payment technology. For example, in China, people from all walks of life use mobile payment services offered by Alipay and WeChat pay for their every financial transaction. Also, this study identified that perceived risk strongly and negatively impacted attitude. Consistent with some prior studies (Chen, 2013; Johnson et al., 2018; Yang et al., 2013), this result indicates that an individual's concerns over the violation of security and privacy associated with the utilization of biometric technologies lead to unfavourable views towards the adoption of these technologies. Moreover, individuals are very sensitive about their biometrics data, which can be used by other parties (i.e., credit card agents and insurance brokers) without their permission. Therefore, they expect to perform confidential and secured financial transactions through e-payment using biometrics payment technologies.

Interestingly, this study found that perceived risk indirectly affected behavioural intention to adopt biometrics authentication for e-payment. This finding contradicts the outcomes of several previous studies (Ogbanufe & Kim, 2018; Shin, 2010; Slade et al., 2015). One plausible reason is that perceived risk loses its importance when consumers exhibit more concern about perceived benefits and trust toward the service provider (Bhuasiri et al., 2016). In this study context, as biometrics authentication for e-payment provides safe, secure, fast, and convenient financial transactions, consumers mainly focus on benefits rather than risks. Moreover, this finding also indicates that service providers are quite efficient in developing trust among consumers. Another possible reason is that as Chinese people have the experience of using biometrics authentication for different purposes such as performing banking activities, fulfilling the immigration process, and performing various government activities, they have lower perceptions about the risk involved with biometrics authentication for e-payment. In short, perceived risk has no direct effect on behavioural intention, rather than behavioural intention affecting attitude toward biometrics authentication for e-payment. This outcome may arise due to the cognitive

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dissonance of the consumers. Also, the author found that perceived trust had a strong and negative impact on perceived risk; this indicates that if individuals' trust level rises, the risk of adopting biometrics payment will be reduced.

Additionally, this study observed that facilitating conditions is a positive and direct antecedent to adopting biometrics authentication for e-payment. This finding implies that users expect various facilitating services (e.g., proper instructions, awareness programs, training, and support) that can lead them toward the appropriate use of biometrics payment. Consumers also look into whether the providers have sufficient capacity to offer this hi-tech service. This study strongly indicates that attitude has a significant and prominent influence on the adoption of biometrics authentication for e-payment.

Finally, this study aims to determine the crucial factors that have a greater impact (total effects) but are less effective in describing attitude and behavioural intention. According to the IPMA data, it is clear that perceived trust, effort expectancy, and perceived risk are in the critical zone due to their lower performance, despite their great importance in moulding attitudes. Furthermore, the presence of facilitating conditions and trust are identified as crucial components in determining behavioural intention. Managers should increase resource allocation to encourage the adoption of biometrics authentication for e-payment by improving perceived trust, effort expectancy, and facilitating conditions.

7. Contributions of the Research

7.1 Theoretical contribution

This study is one of the few that, in the sense of e-payment, explores users' biometrics authentication acceptance behaviour. It has expanded the UTAUT by incorporating attitude to clarify the behavioural intent. This study evaluated the importance of a person's features, i.e., the attitude to the adoption of IS / IT, which was not counted in the original UTAUT model. In addition, this research expands the UTAUT model by introducing two constructs that are relevant to biometrics authentication, such as perceived trust and perceived risk. The existence of perceived trust and perceived risk explicitly supports the model's overall performance. Therefore, this research contributes to the field of system enhancement-based research on the acceptance of biometrics technology. In addition, the addition of perceived risk signifies the risk-taking attitude of customers towards the implementation of biometrics authentication in the sense of e-payment. Therefore, the proposed theoretical model makes substantial contributions to the current IS literature.

In addition, this study used IPMA to examine each latent variable's level of importance and performance in explaining target constructs. As this technique is relatively new in PLS analysis, very few studies applied this analysis. The IPMA provides us with the use of the priority chart to show the order of importance and performance, enabling researchers to visualize better and understand the predictors of the adoption of biometrics authentication. The use of IPMA helps

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distinguish which structures should be given extra concentration and which should be given less significance. It also lets researchers design their future studies on the basis of the constructs' priority.

7.2 Contribution to different stakeholders

The research has valuable insights for managers and practitioners to promote the widespread use of biometrics authentication for e-payments. Given the importance of attitude in influencing user adoption, service providers should prioritise the different aspects that contribute to users' favourable attitudes. To cultivate favourable consumer attitudes, service providers should give priority to augmenting customers' impression of the inherent advantages of utilizing biometric authentication for financial transactions. They are to identify and analyze user requirements, benchmark the systems with the widely accepted systems, and communicate the system's competencies through online and offline media (Slade et al., 2015). Likewise, collaborative efforts with consumers, designers, systems analysts, and software developers can play an important role in designing an effective and user-friendly biometrics system. Besides, decision-makers should undertake strategies to reap the benefits from social influence among customers for the widespread adoption of biometrics payment. They could boost social influence by establishing forums for sharing best-use practices and benefits of the systems; this could create favourable word of mouth and help develop protective measures to counter any unfavourable feedback.

Moreover, developing a trustworthy environment is essential for any technology adoption. In the context of biometrics payment, as consumers need to provide all the credentials, including biometrics data, managerial activities must concentrate on such activities, which can improve the consumers' trust level. Furthermore, the significant impact of perceived risk on attitude implies that biometrics payment service providers must develop and implement adequate privacy and security measures to protect consumers from security breaches and cyber-fraud. Social awareness of security threats should be promoted through online and offline media. Finally, improved facilitating conditions (e.g., technological, human, and infrastructural resources) increase the intention to accept biometrics authentication for e-payment. Therefore, merchants, suppliers, and application developers should build appropriate infrastructures, nurture human resources, and provide users valuable resources related to using biometrics authentication for e-payment.

8. Constraints and Potential Avenues of Research

This paper has certain shortcomings that give rise to prospective avenues for further investigation. Initially, this study utilized the UTAUT model as the theoretical basis. Subsequent investigations might be carried out employing alternative technology adoption models such as UTAUT2, TAM, and IDT. Second, this study does not assess the moderation effect; future studies can assess the moderation effect of different variables such as gender, age and culture. Third, this study has considered the sample taken from P. R. China; future

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researchers should consider wider geographic coverage; even cross-country analysis can be performed. Fourth, it could be interesting to compare different biometrics authentication users in e-payment as the adoption behaviour might vary among various biometrics authentication users. Finally, this study assesses the initial adoption behaviour of biometrics authentication in e-payments; therefore, assessing users' continuance usage behaviour of this technology can be a potential for future research.

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APPENDIX A. MEASUREMENT ITEMS

Construct	Equivalent Items	Sources
Performance expectancy	PE1 – I think that using biometrics authentication is useful to carry out my e-payment tasks. PE2 - I think that using biometrics authentication would enable me to conduct my e-payment tasks more quickly. PE3 - I think that using biometrics authentication for e-payment would increase my productivity. PE4 - I think that using biometrics authentication for e-payment would improve my performance.	(Oliveira et al., 2016; Venkatesh, Thong, & Xu, 2012)
Effort expectancy	EE1 - My interaction with biometrics authentication for e-payment would be clear and understandable. EE2 - It would be easy for me to become skilful at using biometrics authentication for e-payment. EE3 - I would find biometrics authentication for e-payment easy to use.	(Oliveira et al., 2016; Venkatesh et al., 2012)
Social influence	SI1- People who influence my behaviour think that I should use biometrics authentication for e-payment. SI2- People who are important to me think that I should use biometrics authentication for e-payment. SI3- People whose opinions I value prefer that I use biometrics authentication for e-payment. SI4 - Using biometrics authentication for e-payment is a status symbol in my society.	(Oliveira et al., 2016; Venkatesh et al., 2012)
Facilitating Conditions	FC1- Particular instructions regarding the biometrics authentication for e-payment would be available to me. FC2- Biometrics authentication for e-payment is compatible with other systems that I use. FC3- When I have difficulties using biometrics authentication for e-payment, I can get help from service providers.	(Oliveira et al., 2016; Venkatesh et al., 2012)
Perceived Trust	TR1. I think biometrics authentication for e-payment is a trustworthy system. TR2- I think biometrics authentication for e-payment provides reliable and safe financial services. TR3- I trust biometrics authentication for e-payment because they keep my best interests in mind. TR4- I think biometrics authentication for the e-payment system will preserve my biometric data safely.	(Slade et al., 2015; Zhou, 2014)
Perceived Risk	PR1- The use of biometrics authentication for e-payment may cause my personal information to be stolen. PR2 - If I use biometrics authentication for e-	(Johnson et al., 2018; Koenig-Lewis, Marquet,

Construct	Equivalent Items	Sources
	payment, I feel psychological discomfort. PR3- I think that it is unsafe to use biometrics authentication for e-payment. PR4 - I believe that the use of biometrics authentication for e-payment may bring negative consequences.	Palmer, & Zhao, 2015)
Attitude	AT1- Using biometrics authentication for e-payment would be a good idea. AT2 - I like the idea of using biometrics authentication for e-payment. AT3 - Using biometrics authentication for e-payment would be pleasant.	(Chen, 2013; Shin, 2010)
Behavioural Intention	BI1- Given the chance, I intend to use biometrics authentication for e-payment. BI2- I have the intention to use biometrics authentication for e-payment. BI3- I intend to use biometrics authentication for e-payment in the next month.	(Oliveira et al., 2016; Venkatesh et al., 2012)

APPENDIX B. RESPONDENTS' DEMOGRAPHIC PROFILE

Descriptions		Frequency	Percentage
Gender	Male	179	62.81%
	Female	106	37.19%
Educational Qualification	Secondary	32	11.23%
	Bachelor	116	40.70%
	Masters	95	33.33%
	Others	42	14.74%
Age	20-30	155	54.39%
	31-40	90	31.58%
	41-50	30	10.53%
	More than 50	10	3.51%
Occupation	Employee – Private Sector	65	22.81%
	Employee – Public Sector	56	19.65%
	Student	117	41.05%
	Self-employed	43	15.09%
	Unemployed	4	1.40%
User adoption	Adopters	107	37.54%
	Non-adopters	178	62.46%

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