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Examining the determinants of continuance intention to use and the moderating effect of the gender and age of users of NFC mobile payments: a multi-analytical approach

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Abstract
The interest in m-payments through mobile phones to replace the use of cash, credit cards or cheques is rapidly increasing in our society. The present study aims to examine the situation of near field communication (NFC) m-payment services along with the determinants of users' continuance intention. To this intent, a sample of 1840 respondents with experience in using NFC payments participated in an online survey. During the first phase of this research, an structural equation modelling (SEM) technique was used to identify the acceptance predictors of mobile payments as well as to analyse the eventual moderating effect of the gender and age of the users of this tool. The second phase focused on the neural network model's proficiency in assessing the relative impact of the most relevant predictors stemming from the aforementioned SEM analysis. The results obtained revealed subjective norms, risk, perceived usefulness, customer brand engagement and trust as the most significant antecedents of continuance intention towards NFC payments. The study also discusses the managerial implications derived from this research while assessing and suggesting potential user behaviour-based business opportunities for service providers.

Keywords Mobile payment systems · NFC · PLS · ANN · Users' continuance intention

1 Introduction

Smartphones are nowadays at the core of our daily lives [3, 28]. This innovative technology is no longer limited to communication purposes, it is being used for enhanced information exchange services, mobile payments and m-commerce. In this regard, near field communication (NFC) technology has presented new business opportunities for restaurants, public transportation, wireless communications and so on [78]. As the Mobile Economy report from the GSMA [40] revealed with regard to mobile services, in 2017, the statistics for unique users reached over 5 billion people worldwide and a 66% penetration rate. In this sense, Europe (85%), North America (84%) and sub-Saharan Africa (44%) were identified as the areas with the most significant results.

NFC is a key m-payment technology [28] and consists of two main elements: (a) an initiator to establish and manage the communication exchange and (b) a target responding to requests. This technology presents improved functionality since it can operate when the device is not powered on [68]. NFC is used to relay information to the customer's bank via a microchip, a SIM card or a memory card.

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The wide range of uses of the license-fee-free NFC technology, such as paying bills, using public transport tickers and making in-store purchases, can be implemented in all the existing bases of terminals equipped with a dedicated contactless communication chip with significant ease of use, added value and improved security. NFC can also be used to make and receive digital money transfers. All of the aforementioned advantages are especially significant with regard to the continuance intention towards the NFC technology [78]. The research model used in the present study has a dual approach that combines SEM techniques with ANNs (artificial neural networks) [128, 131]. Since the linear nature of SEM (which can function as a standard regression approach to validate hypotheses) usually limits its practical application in the field of complex decision-making processes, the present study introduced an ANN analysis after investigating the advantages of artificial neural networks: (a) detecting linear and non-linear relationships between the main antecedents of the adoption of new technologies [16] and (b) providing researchers with comprehensive, non-compensatory decision-making processes [21]. Early compensatory models in the scientific literature tended to assume that the limitations of a determinant can be mitigated by adopting a better indicator with regard to the adoption of new technology [16]. In this sense, the nature of the assessment of complex adoption of decision-making processes may not be compensatory, leading to unreliable statistical methods [72]. On the other hand, using artificial neural network models ensures strong predictive power and more accurate expectations that overshadow the SEM methods and other traditional regression techniques with regard to logistic and multiple discriminant regression [21, 72]. The aforementioned multi-analytical strategy yielded improved reliability and validity of the obtained results, in other words, the results obtained through SEM analysis were reinforced by the findings from the ANNs [22]. The present study also addressed the challenge presented by neural network analyses of not being capable of conducting causal analyses properly on their own, ANN analyses are not considered to be a good fit for testing research hypotheses [16]. In this vein, the multi-analytical approach used in this study fostered the advantages of SEM techniques in path analysis and incorporated the strong prediction accuracy of ANN models [24]. SEM was only used to test the hypotheses and the reliability of the measurement items, while ANNs identified and tested the determinants and predictors of person-to-person (P2P) mobile payments while assessing their respective impact.

According to the proposals of Shaikh et al. [128] and Karjaluoto et al. [62], the importance of this research is fivefold. First, this research addresses the gap in the existing literature on mobile payments by providing empirical evidence and theoretical support regarding the role of drivers and barriers in mobile payment use. Second, the study proposes a holistic model after a review of the most current literature in this area of research. Third, it explores the moderating effects of gender and age on the influence of these predictors with regard to the continuance intention of the system. Fourth, it carries out a double analysis, SEM and ANN, to verify and contrast the results achieved from the two techniques. Finally, a series of recommendations is made to the actors involved in the process of adoption and use of mobile payments. The obtained results stemmed from an online survey completed by actual users of NFC m-payment systems in Spain. In this sense, the present study is pioneering in the assessment of the continuance intention towards NFC payment systems since the extant literature is rather scarce in this field of knowledge. The study also pioneers an integrating proposal with regard to the revision of the extant scientific literature.

The manuscript consists of the following well-defined sections: Sect. 2 examines the literature in the field of m-payments, introduces the research model and puts forward the hypotheses; Sect. 3 addresses the methodology; Sect. 4 assesses the data and research results; Sect. 5 discusses the findings obtained from this study and their implications; and Sect. 6 serves as a conclusion and identifies the most significant limitations of the present study while discussing avenues for future research.

2 Theoretical background and hypotheses

2.1 Mobile payment systems

The rapid growth of mobile devices in all societies has improved the functionalities of these terminals. One of them concerns mobile payments regardless of the use of a voice, message, NFC or QR code. Mobile payments have turned mobile devices into digital wallets to replace other payment instruments, such as cash, credit cards and bank accounts, and have thus started the digital wallet revolution. Mobile payments are an alternative method of paying for goods, services, bills and receipts and are defined as a payment model that executes payments by electronic means [62, 78].

Multiple classifications have been used to analyse payment systems. According to Liébana-Cabanillas [72], these can be summarized according to the service, technology used and purpose. With regard to the type of service, the most important are the marketing of ticketing services for shows (mobile ticketing), payment for parking spaces (mobile parking), sending money by means of cash remittances (mobile remittances) and payment at the point of sale [mobile point of sale (POS)]. In relation to the type of technology, we highlight payment by sending an SMS (short message service), payment by WAP applications (wireless application protocol), payment by proximity (NFC), payment

by predefined messages [unstructured supplementary service data (USSD)] and payment by voice recognition technology. Finally, depending on the purpose, it is also possible to classify the tools into m-payment, which refers to the actual payment of the purchase made, m-order, which manages mobile orders, m-banking, which refers to access to electronic banking via the device, m-delivery and m-contract, which refers to the delivery of the services acquired to the mobile phone.

2.2 The state of mobile payments in Spain

In recent years, thanks to technology, mobile payments have become a reality. It is therefore, in a physical establishment, now possible to pay with a mobile phone in the same way as with a conventional bank card. Although this method still has its sceptics, it is rapidly expanding throughout the country and already has dozens of applications, so more and more businesses are accepting this form of payment. According to the Mastercard Barometer [88], 83% of shops have a physical POS in Spain, which enables them to receive payments by mobile phone or contactless card. However, the popularity of mobile payments does not mean that society will abandon conventional payments in the near future. According to a survey carried out by HelpMyCash [44], 74% of users between 18 and 35 years old are willing to pay with their mobile phone without any fear, but only 55% of those over 55 years old would dare, motivated mainly by several factors, such as the lack of information regarding the technology that this sector may have or the fear of change, since paying with cash or a card is still a deep-rooted habit. In view of this situation, research such as the present study, which analyses the drivers and barriers among mobile payment users, will make it possible to promote their use among Spaniards and increase their functionalities.

2.3 Adoption of m-payment systems

As explained in the previous sections, mobile payment systems are considered to be a relatively new service, so their level of adoption is not yet as expected. In this context, most research has focused on analysing the factors affecting users' adoption of mobile payments, but few have analysed the intention to continue using mobile payments. To investigate this situation, we conducted a theoretical review of the main research on mobile payments and proposed a holistic model integrating a set of variables according to the objectives of the proposed research (Appendix 1).

Specifically, the proposed model assumes constructs from the Theory of Reasoned Action (TRA) [33] [subjective norms], Perceived Value Theory [148] [performance/quality value], Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) [141] [hedonic motivation], Personal Innovation in Information Technology (PIIT) [2] [personal innovation], Mobile Payment Technology Acceptance Model (MPTAM) [71] [trust and risk] and Expectation Confirmation Model (ECM) [9] (Satisfaction). Additionally, we propose the inclusion of consumer brand engagement as an extension to the TAM [91].

2.4 Development of hypotheses

This study identified specific valuable components within the context of mobile payments and the intention to continue using NFC payment systems. Figure 1 shows the research framework that guided the development of the relationships between the variables.

2.4.1 Subjective norms

Subjective norms are social norms defined by the opinions of users' social networks, friends, families and colleagues that may affect users' decisions to adopt a service made possible by a technological innovation [115]. Venkatesh et al. [141] further explained that subjective norms imposed by family and friends to use a product or service are perceived to be important by consumers and affect their use of a service. In this sense, several studies have used multiple subjective norms to explain users' behavioural intention and continuance intention with regard to mobile payment technologies [35]. Moreover, technology acceptance models such as the TAM, UTAUT, UTAUT2, DOI and so on have included subjective norms as central constructs and found a significant influence on users' continuance intention to use technology [128]. Belanche Gracia et al. [8] posited the need to establish a relationship between subjective norms and personal recommendations of users regarding the continuance intention to use mobile payment services. Ozturk et al. [105] examined the influence of subjective norms while analysing mobile payment services and found it to be especially relevant as a variable that affects users' continuance intention to use mobile payments. In addition, Lu [81] surveyed 323 users of mobile payments in the United States of America and found social influence to be the main antecedent influencing users' continuance intention. They further confirmed that social influence affects mobile payment users' own perceptions as well as their intention to use the new technology in a social environment. These intentions and opinions may influence users' continuance intention regarding existing technological services [153]. Several studies have been conducted in the Asian region, where mobile payments are widely used and extremely popular, they found subjective norms to be the main determinants of mobile payment adoption [65]. In light of all of the above, the following hypothesis is put forward:

H1 Subjective norms positively influence the continuance intention of users of NFC mobile payment systems.

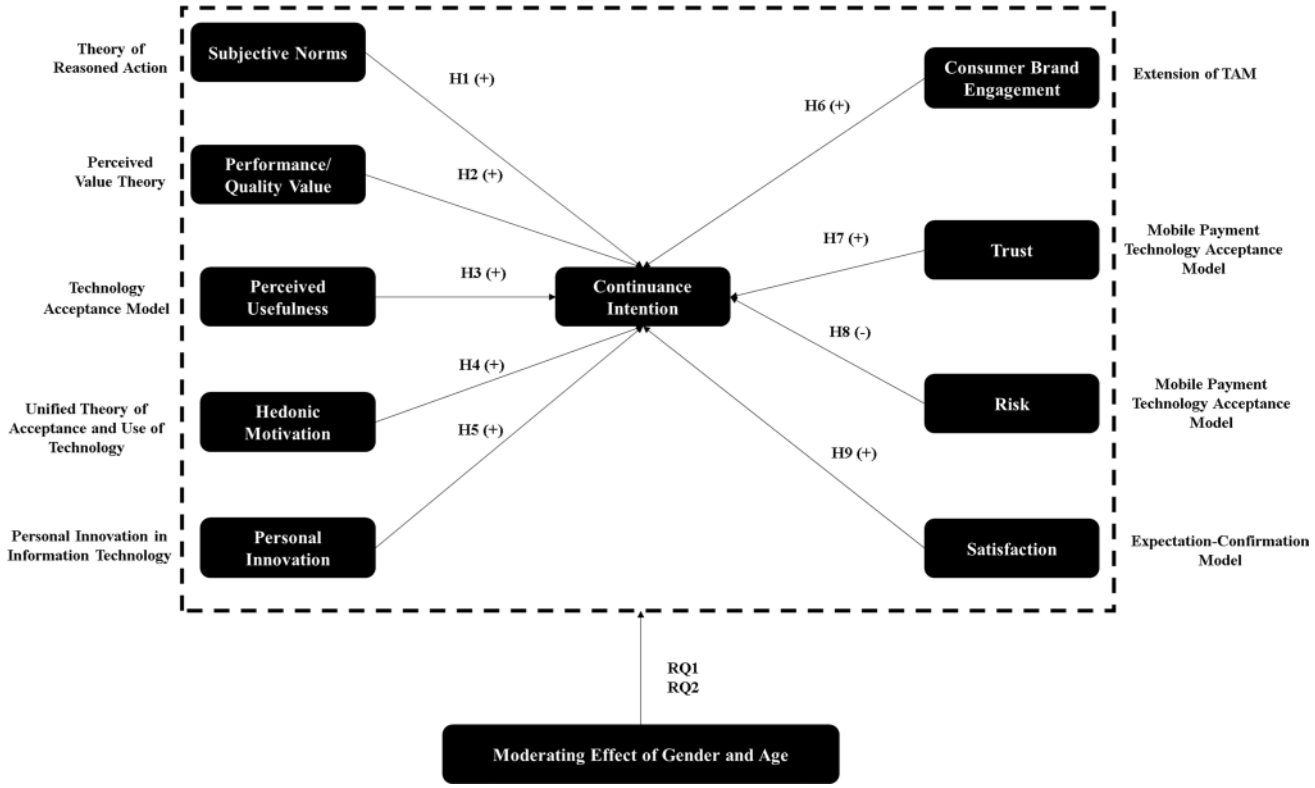

Fig. 1 Conceptual model

2.4.2 Performance/quality value

In the past few years, perceived value has been the focus of several research studies aiming to determine its significance for consumers' adoption of new technology [141]. Perceived value is defined as the utility assessment of a product or service by a consumer based on the received benefits and the cost of the service [28, 148]. The perceived value of a service has been widely explained for different types of services, namely hospitality [86], mobile payments [28, 142], tourism [102] and service delivery [64]. These studies found perceived value to be a key construct in improving the adoption of a service and achieving a competitive advantage. Venkatesh et al. [141] included price value, a central aspect of perceived value, in the proposed UTAUT 2 model, and it has played an important role in various studies related to technology adoption. In this sense, they further explained the positive association between price value derived from perceived value and users' behavioural intention to use a technology. Wang et al. [142] supported the findings of the UTAUT 2 model, explaining perceived value as a significant construct influenced by the usefulness and security of the new technology, they further confirmed that a technology that is perceived to be useful and secure with regard to personal and financial data is also considered to be valuable. Kleijnen et al. [64] investigated perceived value in the context of technologies for mobile service delivery and found perceived value, convenience and risk to be the most significant variables exerting an impact on users' intention in the long term. Slade et al. [130] conducted a similar study, incorporating perceived risk into the value model, and determined the strong effect of perceived value, hedonic motivation and risk on users' willingness to buy or adopt a new service at some point. The perceived value of a product increases its worth in the eyes of the consumers who will eventually use it and retain their association with a product in the long term [148]. Perceived value is a kind of trade-off between price and quality, if the trade-off is beneficial, users will continue using the service in return for their investment. For our research, we used the proposal of Turel et al. [140], which assumes the relationship between performance and quality value, reflecting the design of the service, the consistency and the system quality. In light of all of the above, the following hypothesis is put forward:

H2 Performance/quality value has a positive effect on users' continuance intention in NFC mobile payment systems.

2.4.3 Perceived usefulness

The perceived usefulness of a product or service is measured through the users' perception of the expected benefits

derived from its use. Perceived usefulness was first proposed in the TAM model [31] and has become the most used construct in various technology adoption theories [102, 129]. Perceived usefulness is considered as a main determinant influencing consumer attitude and consumer behavioural intention. However, high perceived usefulness may influence users' inclination and is more likely to foster their continuance intention with regard to a particular service, namely mobile payment services [83]. Lu [81] found perceived usefulness to be a main construct affecting users pre and post the adoption of a technology. The usefulness of a technology is measured through the expected benefits, which may increase with the continued use of a technology [25]. In this sense, users' continuance intention towards the use of a technology may be influenced by perceived usefulness, which motivates users to keep employing a particular service to obtain the maximum benefits from its use. In the context of mobile payment services, [64] corroborated the positive and significant relationship between perceived usefulness and users' continuance intention. In line with similar studies, this research puts forward the following hypothesis:

H3 Perceived usefulness has a positive effect on users' continuance intention towards NFC mobile payment systems.

2.4.4 Hedonic motivation

Motivation is a significant factor driving users' adoption of a technology or service and affecting their continuance intention. Liu and Forsythe [80] defined two categories of consumer motivation, which may influence their intention, these motivations can be hedonic (enjoyment oriented) or utilitarian (goal oriented). They further emphasized that a lack of hedonic motivation may lead to disengagement and risk with regard to the post-purchase experience, which affect users' continuance intention towards a particular technology. Venkatesh et al. [141] defined hedonic motivation as the pleasure that users feel while using a technology innovation, inspiring them to continue using it. In the present research, hedonic motivation is considered to be as relevant as other UTAUT2 variables reported in various previous studies that assessed their impact on users' intention to adopt a technology [95]. Raman and Don [110] used UTAUT2 and examined the hedonic motivation of schoolteachers with regard to online technologies, their findings confirmed that facilitating conditions and hedonic motivation are the most significant factors affecting users' behavioural intention. In a few studies related to the adoption of mobile payment services, hedonic motivation is considered to be an antecedent of perceived ease of use and perceived usefulness while also playing an important role in determining users' behavioural intention towards mobile payment service [21, 22]. In this sense, Thong et al. [138] confirmed the importance of the construct by integrating it with the perceived enjoyment of a user, a factor that significantly affects the user's intention. In a post-adoption context, hedonic motivation is often neglected and has not been discussed in detail [13]. The use of a particular technology over time is influenced by the perceived enjoyment or fun derived from it, which may increase with extended use of the service. Halzack [42] confirmed the strong relationship between users' perceived enjoyment associated with hedonic pleasure and their post-purchase behaviour towards online technologies. In this regard, the present study considers that hedonic motivation is central to improving users' loyalty and intention to continue to use a mobile payment service. In this light, the following hypothesis is put forward:

H4 Hedonic motivation has a positive effect on the continuance intention to use NFC mobile payment systems.

2.4.5 Personal innovation

Various studies in recent years have explored the personality traits of users in the context of mobile payment services. These personality traits may be related to users' personal innovations and attitude towards the use of new technology. In this sense, several studies have found that the inclusion of a personal trait, such as personal innovation, makes the results more rational and easier to understand with regard to mobile payment adoption [61]. Zhao et al. [149] investigated personal innovation in mobile commerce adoption and confirmed it as a main determinant. Only a few studies have found personal innovation to be a significant antecedent acting as a strong moderator of behavioural intention [157]. Yi et al. [156] found that personal innovation can influence behavioural intention directly or be approached as an antecedent of perceived usefulness and ease of use. In this sense, innovativeness increases users' perceived convenience of a service and highlights the benefits and usefulness of the technology. On the other hand, this study found several studies measuring personal innovation through the adoption of a technology with the purpose of determining continued intention to use [81]. By its very nature, innovation is explained as the user's willingness to try out a new technology or service [116]. This explains that innovative individuals are always eager to adopt innovations and may increase their usage if they appreciate their newness and effectiveness [81]. Likewise, innovative users are comfortable with the risks associated with new technology services and are more likely to perceive less danger when using an innovation [132]. Various studies have confirmed that the willingness to adopt new technologies or services has a dynamic nature and that users may continue exploring and trying out new features after the adoption of a technology. Considering the dramatic changes in the needs and lifestyle

of consumers with regard to upcoming and upgraded technologies and services, personal innovation is considered as a key factor to measure the post-adoption continuance intention in mobile payment systems. In light of all of the above, the fifth hypothesis of this study is put forward:

H5 Personal innovation has a positive effect on users' continuance intention to use NFC mobile payment systems.

2.4.6 Customer brand engagement

In the context of mobile payment services, consumer brand engagement plays an important role in enhancing brand loyalty and improving the adoption of technology in the future. Consumer brand engagement can be described as a long-term relationship with and commitment to a product, which are observed through rebuying, spreading positive word of mouth and sticking to a product despite marketing and situation factors that could entice users to engage in switching behaviour [103]. Loyalty to technology is developed based on users' satisfaction with a brand, which not only influences the current consumption of a product but also affects the post-purchase intention [127]. Consumer brand engagement is a key construct that can be described as a strong antecedent of loyalty and users' willingness to purchase a product [104]. Thakur and Srivastava [137] incorporated brand engagement and loyalty into the conceptual technology adoption model and found a strong effect on adoption. Euromonitor International (2014, p. 4) [32] explained the concept of brand engagement in their report, indicating that mobile payment companies try to improve users' loyalty to mobile payment products by enhancing satisfaction and engagement, which in return will increase their continuance intention to use mobile payment services. Brand engagement is moderated by users' type of activity, demand for convenience, expected benefits and access to multiple services, if these advantages are made available to users in the post-adoption process, they will become more engaged with mobile payment technologies, leading to the continued use of the service [62]. Mobile payment technologies encourage users to communicate and engage with others, which can build continued engagement so that users may experience the high value and personal benefits associated with the service [63]. In this light, the following hypothesis is put forward:

H6 Consumer brand engagement has a positive effect on users' continuance intention to use NFC mobile payment systems.

2.4.7 Trust

Trust is central to developing a long-term association between consumers and providers. Trust is also one of the most-studied determinants with regard to technology adoption theories [4, 30, 73, 75, 158–160]. Researchers have posited that trust is the willingness and inclination of a user to be faithful to a particular product or service based on the positive outcome and performance expected from the use of this service. Trust has been explained further through users' ability, perception of reliability and compassion towards the product or service. Previous studies in the literature have assessed the role of trust within various contexts: interpersonal, individual, information, cognition, institutional or affect based [139]. These trust-based contexts further develop a long-term association with technology and influence the continuance intention of services like mobile payments [35, 52]. The present study found the extant scientific literature to be rather scant with regard to research on the role of trust in the post-adoption of a technology [8]. Even if trust is based on the faith required to use a technology, the post-adoption stage of a service is entirely based on users' personal experience and loyalty [35]. The continuance intention of experienced users is influenced by trust, which they develop based on the system's performance and the continuous improvement in the different processes. In regard to mobile payment services, users' continuance intention is affected by the perceived risk and the ambiguity associated with the use of a service. In this sense, trust may act as an important factor to avoid uncertainty while enhancing users' continuance intention to use the technology [8, 32]. In addition, trust measures the strength of the relationship between consumers and service providers and helps to ensure a long-term continuance intention towards the technology. For these reasons, the following hypothesis is put forward:

H7 Perceived trust has a positive effect on users' continuance intention to use NFC mobile payment systems.

2.4.8 Perceived risk

Uncertainties related to the performance of mobile transactions may lead to privacy risk or security. Consumers believe that perceived risk is the most significant barrier to online and mobile transactions [28, 106]. In this sense, perceived risk can be described as the threat or uncertainty related to the use of a new technology or service [23]. Researchers have widely discussed perceived risk as a key variable moderating the behavioural intention of users and influencing their pre- or post-purchase behaviour [137]. This previous research has posited that users are constantly worried about the safety and privacy of their personal and bank details while using mobile payment technology and that this attitude

negatively influences their intention to adopt a service [76, 77]. Perceived risk also plays an important role in the context of mobile payment services. A lack of experience with existing mobile payment systems and the subjective benefits associated with their use increase consumers' perceived risk with regard to mobile payments [37]. In similar research conducted by Lu et al. [82], the negative association between privacy risk and continuance intention was corroborated through the study of a group of Chinese users of mobile payment services, the study also proposed that users' continuance intention in mobile services is affected by perceived privacy risk due to a lack of experience and awareness. Privacy incursions and loss of personal and transaction data are the biggest concern among consumers. On the other hand, increasing users' awareness and knowledge of mobile commerce services may reduce the perceived risk and serve as a preemptive strategy for companies [97]. Moreover, increasing users' awareness of the risk factors associated with mobile payment services leads to a dramatic improvement of their continuance intention to use the technology [25]. The present study supports the previous findings and also posits that perceived risk is a significant moderator of users' continuance intention [15]. In this light, the following hypothesis is put forward:

H8 Perceived risk has a negative effect on users' continuance intention to use NFC mobile payment systems.

2.4.9 Satisfaction

Several studies in the literature on mobile payment services have found that satisfaction is the most significant driver of continuance intention [26]. These studies defined satisfaction as the overall opinion and experience that a user feels while using a technology service. The research by Hsu et al. [53] corroborated these findings and posited that continuance intention is derived from users' overall satisfaction with the features and benefits of a particular technology, further confirming the positive relationship between satisfaction and continuance intention in mobile payment technology. In this sense, satisfaction increases the long-term use of a product, users who are disappointed with the service and those that have had a bad experience with it may stop using that particular technology [138]. Satisfaction is one of the most-used variables to measure post-adoption consumer behaviour towards any product or service [53]. Jamal and Naser [59] evaluated the experience of mobile banking users in the USA and found that consumers who are satisfied with the benefits of a service always spread positive word of mouth about it and recommend it to others. Arbore and Busacca [5] conducted a similar study that posited that banking services are evaluated based on the quality of the associated services and their functionality as factors that help to explain the satisfaction with and eventually improve the adoption of a service. Consumer satisfaction might be achieved by providing continuous value-added services to improve convenience and effectiveness. Therefore, by providing adequate levels of convenience, the user may continue to use the technology in the long term while increasing the frequency of use over time. This counteracts the occurrence of consumer switching behaviour between the different technologies available and maintains a high continuance intention. In line with previous research, which has proposed a strong influence of satisfaction on users' behavioural continuance [35], this study puts forward the following hypothesis:

H9 Satisfaction has a positive effect on users' continuance intention to use NFC mobile payment systems.

2.4.10 Moderating effect of gender and age

To achieve the objectives of the research, the study proposed to include the main moderating effects that the literature has considered to be relevant to the relationships of many of the existing models (Ha et al. [41]). We analysed the possible effects of gender and age variables on users' continuance intention to use NFC mobile payment systems. Both variables have been analysed in different contexts, such as e-commerce [111] and mobile commerce [87]. Despite this, research studying both variables in relation to mobile payment systems has been very limited, and we therefore consider their analysis to be extremely useful [17, 57]. Against this background, we propose the following research questions:

RQ1 Gender moderates the impact of antecedents on users' continuance intention to use NFC mobile payment systems.
RQ2 Age moderates the impact of antecedents on users' continuance intention to use NFC mobile payment systems.

3 Research methodology

3.1 Measurement development

The data used in this research were collected in three phases. First, an initial review of the methodology and scales for this study was performed by a panel of five academics with expertise in payment systems and five academic experts in the same discipline. This review was carried out on the basis of personal interviews, revising some of the proposed scales and adapting others to attain the main objectives of the study. This first phase was conducted in the second half of October 2018. After the review by the panel of experts, a

questionnaire was divided into three thematic blocks: control questions, questions on the object of the research and questions on socio-demographic data.

After this first phase, a pre-test was carried out through a teaching support platform, administered by the authors of this manuscript. Following this quantitative methodology, a sample of students was approached in the second half of November 2018 in Spain. This design focused on the evaluation and refinement of the questionnaire to examine the acceptance level, dimensionality, reliability and validity of the proposed scales. Finally, after verifying the scales, final validation of the questionnaire was conducted on a sample selected for this purpose.

Appendix 2 shows the items used in this study and the supporting literature for each construct. Four items were used to measure subjective norms [1, 135], performance/quality value [140], perceived usefulness [71, 109], perceived risk [71, 74] and satisfaction [11, 58]. Five measurement items were used to analyse hedonic motivation [55] and perceived trust [107]. There were seven measurement items for consumer brand engagement [12]. Finally, three measurement items were adopted for personal innovation [2, 83] and continuance intention [9, 51].

3.2 Data collection and sample

This research surveyed Spanish consumers over 18 years of age who owned a mobile phone and had used NFC mobile payment systems during the 12 months before the study was conducted. Since a sampling frame was unavailable, convenience sampling was employed instead. Following a "snowball" procedure, researchers shared a link to the online questionnaire through social media and e-mail lists [58]. A total of 1840 responses were found to be useable after excluding partial returns and missing data (51 responses) with a sampling error of 2.285% in the estimation of a proportion. The sample characteristics (Table 1) are considered by the Spanish National Statistics Office as being representative of a population that is likely to adopt new technologies [136].

3.3 PLS methodology

This research assessed data using the partial least squares (PLS) method in a structural equation model (SEM) analysed using SmartPLS 3 software [114]. The use of PLS does not assume that the sample distribution is normal multivariate and the observations are independent [6]. This manuscript followed the PLS-SEM variance-based method, which combines principal component analysis with ordinary least squares regressions [89]. In addition, this study used a composite-based SEM that diverges from common factor-based SEM [i.e., covariance-based SEM (CBSEM)].

Table 1 Demographic profiles of the respondents

Variable	Frequency	Percentage
Gender		
Male	975	52.99
Female	865	47.01
Age		
18–24	607	32.99
25–34	584	31.74
35–44	313	17.01
45–54	220	11.96
55–65	60	3.26
Over 65	56	3.04
Level of studies		0.00
No studies	128	6.96
Elementary school studies	203	11.03
High school studies	1177	63.97
Undergraduate university studies	332	18.04
Income level		
No income	110	5.98
Under 650 €	111	6.03
651–900 €	165	8.97
901–1200 €	240	13.04
1201–1500 €	202	10.98
1501–1800 €	165	8.97
1801–2400 €	280	15.22
2401–3000 €	220	11.96
3001–6000 €	219	11.90
Over 6000 €	128	6.96
Occupation		
Full-time job	866	47.07
Part-time job	404	21.96
Studies and works part-time	36	1.96
Student	149	8.10
Unemployed	202	10.98
Retired or pre-retirement	55	2.99
Household work	128	6.96

The research methodology also used the bootstrapping technique (5000) with the purpose of checking the relevance of the coefficients that had previously been assessed through the PLS analysis. This technique provides subsamples with randomly extracted observations (including replacements) [41].

4 Results

4.1 Reliability and validity of the measurement instrument

The suitability of the measurement scales was assessed through several measures of reliability and validity. First,

three methods were used to measure reliability: Cronbach's alpha (α), the average variance extracted (AVE) and Dijkstra–Henseler's rho (rho_A). Table 2 shows that all the constructs are reliable, all the values being above the recommended thresholds: Cronbach's alpha is 0.6 [29], rho_A is 0.7 and the AVE is 0.5 [100].

A principal component analysis (PCA) was subsequently carried out to verify the degree of unidimensionality of the scales. The results show correlations by blocks of items, allowing them to be grouped into constructs. In addition, high communalities ($\lambda > 0.5$) were found in the variables, which imply that they are all fairly well represented in the

Table 2 Indicators for the evaluation of the measurement model

Construct	Item	Loadings	*p* value	α	rho_A	AVE
Subjective norms	SN1	0.869	0.000	0.924	0.925	0.752
	SN2	0.878	0.000			
	SN3	0.828	0.000			
	SN4	0.892	0.000			
Performance/quality value	PQV1	0.982	0.000	0.951	0.953	0.828
	PQV2	0.871	0.000			
	PQV3	0.877	0.000			
	PQV4	0.905	0.000			
Perceived usefulness	PU1	0.871	0.000	0.940	0.941	0.798
	PU2	0.898	0.000			
	PU3	0.872	0.000			
	PU4	0.932	0.000			
Hedonic motivation	HM1	0.980	0.000	0.919	0.952	0.693
	HM2	0.803	0.000			
	HM3	0.708	0.000			
	HM4	0.857	0.000			
	HM5	0.792	0.000			
Personal innovation	PI1	0.963	0.000	0.973	0.973	0.924
	PI2	0.956	0.000			
	PI3	0.965	0.000			
Consumer brand engagement	CBE1	0.889	0.000	0.944	0.945	0.701
	CBE2	0.878	0.000			
	CBE3	0.897	0.000			
	CBE4	0.834	0.000			
	CBE5	0.740	0.000			
	CBE6	0.785	0.000			
	CBE7	0.827	0.000			
Perceived trust	TRUST1	0.868	0.000	0.972	0.973	0.875
	TRUST2	0.945	0.000			
	TRUST3	0.932	0.000			
	TRUST4	0.942	0.000			
	TRUST5	0.986	0.000			
Perceived risk	PR1	0.770	0.000	0.922	0.984	0.761
	PR2	0.749	0.000			
	PR3	0.898	0.000			
	PR4	0.980	0.000			
Satisfaction	SAT1	0.898	0.000	0.950	0.951	0.826
	SAT2	0.868	0.000			
	SAT3	0.956	0.000			
	SAT4	0.912	0.000			
Continuance intention	CI1	0.968	0.000	0.973	0.973	0.923
	CI2	0.953	0.000			
	CI3	0.960	0.000			

factor space and that the factor loads exceed the recommended minimum thresholds ($R^2 > 0.5$). This analysis shows that the measurement scales have a unidimensional structure.

A confirmatory factor analysis (CFA) was carried out to verify the convergent and discriminant validity of the scales. The convergent validity was evaluated through the factorial loads of the indicators. It was found that the coefficients were significantly different from zero and that the loadings were higher than 0.7 in all cases. Regarding the discriminant validity, the variances were significantly different from zero and the correlation between each pair of scales was not higher than 0.9 [45] (Table 3). Therefore, all the constructs had appropriate measurement properties.

4.2 Common method bias

Harman's single-factor test was used to examine the effect of common method bias (CMB). Should a single factor have total variance above 50%, it is likely that CMB will influence the data and, consequently, the empirical outcomes (Podsakoff et al. [114]). In our study, the total variance for a single factor was 48.85%. When the complete set of factors was present in the model, 79.71% of the variance was explained. This suggests that it is unlikely that common method bias exists [58].

4.3 Importance–performance map analysis

Additionally, the total effect was analysed through importance–performance map analysis (IPMA). According to Schloderer et al. [119], IPMA allows researchers to identify the importance (based on the total effects) and performance (based on the average latent variable score from 0 to 100) of exogenous constructs for a specific endogenous construct, which could help in highlighting the specific focus within a complex research mode. Table 4 presents the IPMA results for the criterion of "continuance intention". The results show that perceived usefulness affects most constructs in the proposed model (total effect = 0.365), as predicted by the performance analysis (IPMA = 49.77%). On the other hand, the results obtained for the rest of the variables meet the expected values with regard to importance and performance.

4.4 Assessment of multivariate assumptions

Before further data analyses were performed, the multivariate assumptions of normality, linearity, multicollinearity and homoscedasticity were tested. The normality of the data set was examined through the Kolmogorov–Smirnov test [48], and the results are presented in Table 5. Since the two-tailed asymptotic significance is 0.000, that is, less than 0.05, it is

Table 4 IPMA results

	Total effects (importance)	Index value (performance) (%)
Continuance intention		43.18
Engagement	0.122	58.61
Hedonic motivation	−0.036	69.03
Perceived usefulness	0.365	49.77
Perceived value	0.112	57.05
Personal innovation	0.134	30.73
Risk	−0.077	51.25
Satisfaction	−0.048	61.33
Subjective norms	0.256	44.31
Trust	0.200	54.12

Table 3 Discriminant validity

	CI	CBE	HM	PU	PQV	PI	PR	SAT	SN	PT
CI	**0.961**	0.702	0.496	0.814	0.721	0.559	0.254	0.382	0.793	0.723
CBE	0.705	**0.838**	0.779	0.764	0.771	0.350	0.201	0.471	0.679	0.758
HM	0.510	0.776	**0.832**	0.583	0.662	0.132	0.150	0.459	0.477	0.587
PU	0.814	0.767	0.596	**0.894**	0.798	0.496	0.201	0.460	0.773	0.702
PVQ	0.723	0.772	0.672	0.799	**0.910**	0.369	0.286	0.538	0.708	0.705
PI	0.559	0.355	0.146	0.495	0.370	**0.961**	0.049	0.164	0.639	0.423
PR	−0.260	−0.205	−0.165	−0.209	−0.294	0.022	**0.872**	0.137	0.171	0.305
SAT	0.383	0.471	0.462	0.461	0.537	0.165	−0.140	**0.909**	0.416	0.440
SN	0.793	0.683	0.492	0.772	0.709	0.637	−0.182	0.417	**0.867**	0.708
PT	0.723	0.758	0.592	0.702	0.705	0.424	−0.307	0.439	0.708	**0.935**

CI continuance intention, *SN* subjective norms, *PQV* performance/quality value, *PU* perceived usefulness, *PI* personal innovation, *CBE* consumer-brand engagement, *TR* perceived trust, *RISK* perceived risk, *SAT* satisfaction

The bold value indicates Fornell-Larcker criterion (below the main diagonal) and Heterotrait-Monotrait Ratio (HTMT) (above the main diagonal).

clear that the data are not normally distributed [144]. Hence, PLS-SEM was used in this study, since it does not require normal data distribution [69].

The linearity of the relationships between variables was examined using the ANOVA test of linearity [69], and the results are presented in Table 6. The results indicate that there are linear relationships between the dependent (continuance intention) and independent variables since all the *p* values are below 0.05. However, the results also show that, out of eight relationships, four reveal a statistically significant deviation from linearity; specifically, the relationships between performance/quality value, personal innovation, consumer brand engagement and satisfaction on one hand and continuance intention on the other hand possess a strong non-linear component.

Multicollinearity indicates that independent variables are highly correlated with each other [47], and it can cause the statistical results to be invalid [68]. Therefore, multicollinearity analysis was performed and the results are presented in Table 7. Since all the variance inflation factor (VIF) values are less than 10 and all the tolerances are higher than 0.10 [69], we may conclude that there is no issue of multicollinearity.

Finally, homoscedasticity refers to the uniform distribution of the output variance [47], and it is usually assessed based on the dispersion of regression standardized residuals [144]. Scatter plot analysis showed that the regression standardized residuals were evenly distributed along the straight line, which indicates that homoscedasticity is achieved [69].

4.5 Evaluation of the structural model

The actual assessment of the structural model was carried out following the guidelines suggested by Hair et al. [40] and Henseler et al. [46]. The procedure involves the measurement of the Stone–Geisser R^2 and Q^2 coefficients as well as the size of effect (f^2) and the standardized root mean square residual (SRMR) coefficients. Firstly, this study examined the R^2 as this indicator reveals the amount of variance of the constructs as explained by the model. The proposed model explains 76.1% of the variance of the intention to use construct, which is the object of this research.

Secondly, the standardized regression weights were analysed to assess the relative weight of the factors with regard to the endogenous variables. According to Chin [20], values higher than 0.3 are recommended, however, values higher than 0.2 are allowed in exploratory studies or when applied to different areas of knowledge or sectors. The relationships between performance/quality value and continuance intention, personal innovation and continuance intention, consumer brand engagement and continuance intention, perceived trust and continuance intention, and perceived risk and continuance intention present a lower weight than the recommended minimum. In addition, the relationship between satisfaction and continuance intention has an inverse sense with regard to the expected result.

On the other hand, the estimator variable provided by the Stone–Geisser or Q^2 test [38, 131] through a blindfolding procedure (omission distance = 7) was used to analyse the predictive capacity of the dependent constructs and endogenous variables, offering higher values than the recommended minimum (0.4). In the case of this study, all the values exceed the reference value.

In addition, the effect size (f^2) verified the suitability of the proposed model. This coefficient determines whether an independent latent variable has a substantial impact on a dependent latent variable. Values of f^2 between 0.02 and 0.15, between 0.15 and 0.35, and 0.35 or higher indicate that an exogenous latent variable has a small, medium, or large effect, respectively [20]. All the relationships detailed in Table 8 show a trivial, almost negligible effect.

Finally, the value of the SRMR ratio (standardized root mean square residual) [45] allows researchers to compare the difference between the observed correlation and the predicted correlation as a measure of model fit. A value of less than 0.08 is considered acceptable. The model used in this study presents a value close to this threshold (SRMR = 0.049) and therefore the fit of the proposed model is considered to be partially correct. The results from the analysis corroborate the idea that all the proposed variables significantly affect the use intention except for hedonic motivation and satisfaction, the former cannot be empirically supported whilst the latter has an inverse sense with regard to the expected result.

Once the global model had been analysed and we had determined whether there were differences at the level of the indicators in terms of the moderating variables, we checked whether those differences also existed at the structural level. Accordingly, we carried out a multi-group analysis (MGA) [118]. To this end, the sample was divided into two groups according to the respondents' gender (men = 862, women = 978) and median age (< 35 years: young users = 1191; ≥ 35 years: old users = 649). Specifically, for each variable, the path coefficients of the two resulting structural models were compared, and we evaluated whether significant differences existed through a Student's t-test for independent samples [94]. In addition, the moderating effect of gender and age was demonstrated by finding significant differences in two of the proposed relationships, satisfaction and continuance intention and perceived risk and continuance intention, respectively (Table 9).

4.6 Artificial neural network analysis

One of the main shortcomings of PLS, SEM and other conventional statistical techniques is that they are able to test

Table 5 One-sample Kolmogorov–Smirnov test for normal distribution

	N	Normal parameters[a,b]		Most extreme differences			Kolmogorov–Smirnov Z	Asymp. Sig. (2-tailed)
		Mean	SD	Absolute	Positive	Negative		
SN1	1840	3.94	1.493	0.199	0.157	−0.199	8.556	0.000
SN2	1840	3.53	1.535	0.187	0.151	−0.187	8.010	0.000
SN3	1840	3.40	1.669	0.180	0.128	−0.180	7.701	0.000
SN4	1840	3.73	1.543	0.198	0.147	−0.198	8.483	0.000
PQV1	1840	4.22	1.577	0.175	0.129	−0.175	7.504	0.000
PQV2	1840	4.46	1.447	0.176	0.137	−0.176	7.535	0.000
PQV3	1840	4.58	1.430	0.169	0.132	−0.169	7.251	0.000
PQV4	1840	4.43	1.360	0.191	0.160	−0.191	8.194	0.000
PU1	1840	4.13	1.663	0.169	0.098	−0.169	7.246	0.000
PU2	1840	4.02	1.604	0.177	0.115	−0.177	7.589	0.000
PU3	1840	3.67	1.626	0.176	0.124	−0.176	7.530	0.000
PU4	1840	4.11	1.630	0.176	0.103	−0.176	7.568	0.000
HM1	1840	4.83	1.603	0.178	0.088	−0.178	7.641	0.000
HM2	1840	5.14	1.390	0.166	0.106	−0.166	7.119	0.000
HM3	1840	5.68	1.466	0.244	0.183	−0.244	10.483	0.000
HM4	1840	5.11	1.404	0.167	0.101	−0.167	7.171	0.000
HM5	1840	5.24	1.422	0.191	0.108	−0.191	8.199	0.000
PIN1	1840	2.86	1.700	0.196	0.196	−0.157	8.405	0.000
PIN2	1840	2.84	1.702	0.200	0.200	−0.150	8.599	0.000
PIN3	1840	2.83	1.705	0.207	0.207	−0.154	8.865	0.000
CBE1	1840	4.43	1.285	0.206	0.204	−0.206	8.831	0.000
CBE2	1840	4.28	1.438	0.189	0.150	−0.189	8.118	0.000
CBE3	1840	4.48	1.430	0.161	0.118	−0.161	6.919	0.000
CBE4	1840	4.55	1.346	0.174	0.141	−0.174	7.483	0.000
CBE5	1840	4.80	1.392	0.156	0.118	−0.156	6.710	0.000
CBE6	1840	4.72	1.319	0.162	0.145	−0.162	6.964	0.000
CBE7	1840	4.41	1.358	0.190	0.169	−0.190	8.133	0.000
TRUST1	1840	4.40	1.401	0.190	0.163	−0.190	8.146	0.000
TRUST2	1840	4.15	1.380	0.211	0.183	−0.211	9.057	0.000
TRUST3	1840	4.23	1.354	0.216	0.187	−0.216	9.265	0.000
TRUST4	1840	4.29	1.377	0.206	0.184	−0.206	8.850	0.000
TRUST5	1840	4.18	1.443	0.202	0.168	−0.202	8.677	0.000
PR1	1840	4.09	1.661	0.164	0.130	−0.164	7.028	0.000
PR2	1840	3.90	1.590	0.161	0.159	−0.161	6.898	0.000
PR3	1840	4.11	1.610	0.159	0.138	−0.159	6.836	0.000
PR4	1840	4.16	1.663	0.146	0.138	−0.146	6.253	0.000
SAT1	1840	4.68	1.382	0.165	0.153	−0.165	7.081	0.000
SAT2	1840	4.70	1.304	0.163	0.160	−0.163	7.001	0.000
SAT3	1840	4.61	1.281	0.191	0.191	−0.187	8.188	0.000
SAT4	1840	4.74	1.304	0.169	0.159	−0.169	7.234	0.000
CI1	1840	3.60	1.684	0.161	0.117	−0.161	6.888	0.000
CI2	1840	3.58	1.674	0.173	0.122	−0.173	7.426	0.000
CI3	1840	3.60	1.705	0.160	0.122	−0.160	6.865	0.000

[a]Test distribution is normal

[b]Calculated from data

Table 6 ANOVA test of linearity

			Sum of squares	*df*	Mean square	F	Sig
CI * SN	Between groups	(Combined)	2833.286	24	118.054	100.443	0.000
		Linearity	2800.963	1	2800.963	2383.140	0.000
		Deviation from linearity	32.323	23	1.405	1.196	0.237
CI * PQV	Between groups	(Combined)	2502.968	24	104.290	76.836	0.000
		Linearity	2401.620	1	2401.620	1769.387	0.000
		Deviation from linearity	101.347	23	4.406	3.246	0.000
CI * PU	Between groups	(Combined)	3043.925	24	126.830	119.734	0.000
		Linearity	3013.458	1	3013.458	2844.845	0.000
		Deviation from linearity	30.467	23	1.325	1.251	0.190
CI * HM	Between groups	(Combined)	1285.630	29	44.332	21.799	0.000
		Linearity	1114.509	1	1114.509	548.039	0.000
		Deviation from linearity	171.120	28	6.111	3.005	0.000
CI * PI	Between groups	(Combined)	1532.017	18	85.112	45.127	0.000
		Linearity	1468.076	1	1468.076	778.390	0.000
		Deviation from linearity	63.941	17	3.761	1.994	0.009
CI * CBE	Between groups	(Combined)	2415.302	42	57.507	40.507	0.000
		Linearity	2251.793	1	2251.793	1586.107	0.000
		Deviation from linearity	163.509	41	3.988	2.809	0.000
CI * TR	Between groups	(Combined)	2502.951	30	83.432	61.264	0.000
		Linearity	2458.464	1	2458.464	1805.266	0.000
		Deviation from linearity	44.486	29	1.534	1.126	0.293
CI * RISK	Between groups	(Combined)	367.767	24	15.324	6.048	0.000
		Linearity	289.040	1	289.040	114.077	0.000
		Deviation from linearity	78.727	23	3.423	1.351	0.123
CI * SAT	Between groups	(Combined)	764.516	24	31.855	13.759	0.000
		Linearity	670.578	1	670.578	289.649	0.000
		Deviation from linearity	93.938	23	4.084	1.764	0.014

CI continuance intention, *SN* subjective norms, *PQV* performance/quality value, *PU* perceived usefulness, *PI* personal innovation, *CBE* consumer-brand engagement, *TR* perceived trust, *RISK* perceived risk, *SAT* satisfaction

Table 7 Multicollinearity test

Coefficients[a]								
Model		Unstandardized coefficients		Standardized coefficients	t	Sig.	Collinearity statistics	
		B	SE	Beta			Tolerance	VIF
1	(Constant)	−0.356	0.126		−2.833	0.005		
	SN	0.258	0.025	0.220	10.342	0.000	0.330	3.027
	PQV	0.115	0.027	0.095	4.242	0.000	0.301	3.325
	PU	0.364	0.024	0.333	15.034	0.000	0.306	3.264
	HM	−0.037	0.025	−0.029	−1.525	0.127	0.422	2.367
	PI	0.132	0.016	0.134	8.213	0.000	0.567	1.764
	CBE	0.121	0.033	0.087	3.670	0.000	0.267	3.750
	TR	0.201	0.025	0.162	7.920	0.000	0.361	2.772
	RISK	−0.077	0.015	−0.069	−5.195	0.000	0.861	1.162
	SAT	−0.048	0.019	−0.036	−2.472	0.014	0.708	1.413

CI continuance intention, *SN* subjective norms, *PQV* performance/quality value, *PU* perceived usefulness, *PI* personal innovation, *CBE* consumer-brand engagement, *TR* perceived trust, *RISK* perceived risk, *SAT* satisfaction

[a]Dependent variable: CI

Table 8 Evaluation of the structural model (bootstrapping = 5000)

	Path coefficient (p value)	Confidence interval (2.5%; 97.5%)	f^2	Q^2	R^2	SRMR
H1 (+): Subjective Norms → Continuance Intention	0.246***	(0.163; 0.274)	0.058			
H2 (+): Performance/ Quality Value → Continuance Intention	0.067***	(0.044; 0.140)	0.009			
H3 (+): Perceived Usefulness → Continuance Intention	0.379***	(0.277; 0.389)	0.124			
H4 (+): Hedonic Motivation → Continuance Intention	−0.039 (n.s.)	(−0.068; 0.012)	0.001			
H5 (+): Personal Innovation → Continuance Intention	0.113***	(0.097; 0.173)	0.038			
H6 (+): Costumer Brand Engagement → Continuance Intention	0.078***	(0.037; 0.136)	0.007			
H7 (+): Perceived Trust → Continuance Intention	0.151***	(0.113; 0.208)	0.034			
H8 (-): Perceived Risk → Continuance Intention	−0.07***	(−0.099; −0.041)	0.015			
H9 (+): Satisfaction → Continuance Intention	−0.043***	(−0.067; −0.006)	0.003			
Continuance Intention				0.649	0.726	0.049

*** $p \leq 0.001$; *n.s.* not significance

only linear relationships among different variables [73, 75]. To deal with existing non-linearity issues, confirmed by the ANOVA test of linearity, an artificial neural network (ANN) approach was introduced. ANNs belong to a class of artificial intelligence techniques of which the structure and operation are based on the basic principles of the operation of the human brain [99]. ANNs have been proven to be rather efficient with complex non-linear problems and predictive analysis [73, 75, 99]. ANNs are also robust and flexible models, which, unlike some linear techniques, do not require multivariate assumptions (i.e. normality, linearity, homoscedasticity and multicollinearity) to be fulfilled [68, 113]. In this sense, ANN models are consistently more accurate than linear models [134]. However, because of one of the main drawbacks of ANN models, that is, their "black box" nature of their operating algorithm, they cannot be used for hypothesis testing of causal relationships [69]. Therefore, this study adopted a two-step multi-analytical approach. In the first step, the significant determinants of continuance intention to use mobile payments were determined using PLS. In the second step, an ANN model ranked the impact of the significant predictors of continuance intention, obtained by PLS, with higher accuracy and considering the non-linearities of the relationships. This hybrid approach, combining a linear technique with an ANN analysis, has already been employed successfully in acceptance studies of mobile payments and credit cards [58], mobile learning [134], cloud computing [122], mobile commerce [21, 73, 75, 145], wearable payments [67], mobile banking [126], mobile government [124], social media usage [69, 70], Facebook usage [125], Facebook commerce [68] and many other areas.

As a basic ANN model, a multilayer perceptron (MLP) with a feed-forward back-propagation training algorithm was used [58, 69] and simulated in SPSS 20. The MLP model consists of several layers (one input, one or more hidden and one output) of highly interconnected neurons, that is, each neuron from a particular layer is connected with all the neurons in the next layer through adaptable links called synaptic weights. The number of hidden layers depends on the complexity of the problem to be solved [99], but technology adoption studies have posited that a single hidden layer is usually enough [58] as it enables the modelling of any continuous function [73, 75, 99]. The number of neurons in the input layer corresponds to the number of inputs—the significant antecedents determined by PLS—which is eight in the case of the present study. The number of neurons in the output layer corresponds to the number of outputs—dependent variables, which in our case is one—continuance intention. Finally, the number of neurons in the hidden layer also depends on the complexity of the problem, and there is no exact rule to determine it [73, 75]. In the present study, it was determined automatically through simulation software [58] and was set to seven. The inputs into each neuron in the hidden and output layers are multiplied by the corresponding synaptic weights and summed, and, to obtain the output from the neurons, this signal is fed through an activation function, such as sigmoid, hyperbolic tangent, identity or arctangent. In the present study, sigmoid was used as an activation function in both layers [58, 68, 73, 75]. The final ANN model is presented in Fig. 2.

The research sample was divided into training and testing sub-samples, using a 90%:10% ratio [22, 58]. To avoid over-fitting, one of the most common issues with ANN models [73, 75], a cross-validation routine with ten folds was applied [58, 69]. The predictive accuracy of ANN models is usually estimated using the root mean square error (RMSE) [58]. The RMSE values of the training and testing data sets for all ten ANNs are calculated and presented in Table 10.

The values of RMSE are in the range of 0.1006–0.1055 for the training data and 0.0866–0.1243 for the testing data, indicating the high precision and predictive power of the model [58, 68]. To estimate further the performance of the

Table 9 Multigroup analysis (gender and age)

	Path man	Path women	t-value man	t-value women	*p* value man	*p* value women	Path-diff	*p* value diff
H1 (+): Subjective Norms → Continuance Intention	0.271	0.181	7.354	4.490	0.000	0.000	0.090	0.102
H2 (+): Performance/ Quality Value → Continuance Intention	0.075	0.099	2.255	2.717	0.024	0.007	0.025	0.623
H3 (+): Perceived Usefulness → Continuance Intention	0.349	0.325	8.408	8.131	0.000	0.000	0.024	0.677
H4 (+): Hedonic Motivation → Continuance Intention	−0.022	−0.025	0.710	0.984	0.478	0.325	0.003	0.932
H5 (+): Personal Innovation → Continuance Intention	0.096	0.161	3.839	5.671	0.000	0.000	0.065	0.088
H6 (+): Costumer Brand Engagement → Continuance Intention	0.119	0.077	3.197	2.360	0.001	0.018	0.042	0.393
H7 (+): Perceived Trust → Continuance Intention	0.145	0.164	4.041	5.040	0.000	0.000	0.019	0.691
H8 (−): Perceived Risk → Continuance Intention	−0.063	−0.071	3.045	3.467	0.002	0.001	0.008	0.774
H9 (+): Satisfaction → Continuance Intention	−0.086	0.001	3.604	0.030	0.000	0.976	0.086	**0.007**
	Path < 35 years: Young users	Path ≥ 35 years: Old users	t-value < 35 years: Young users	t-value ≥ 35 years: Old users	*p* value < 35 years: Young users	*p* value ≥ 35 years: Old users	Path-diff	*p* value diff
H1 (+): Subjective Norms → Continuance Intention	0.183	0.273	5.287	6.221	0.000	0.000	0.090	0.115
H2 (+): Performance/ Quality Value → Continuance Intention	0.090	0.099	2.756	2.601	0.006	0.009	0.009	0.864
H3 (+): Perceived Usefulness → Continuance Intention	0.309	0.377	8.146	8.712	0.000	0.000	0.068	0.263
H4 (+): Hedonic Motivation → Continuance Intention	−0.038	0.000	1.597	0.003	0.110	0.997	0.038	0.368
H5 (+): Personal Innovation → Continuance Intention	0.162	0.104	6.640	3.382	0.000	0.001	0.058	0.148

Table 9 (continued)

	Path < 35 years: Young users	Path ≥ 35 years: Old users	t-value < 35 years: Young users	t-value ≥ 35 years: Old users	*p* value < 35 years: Young users	*p* value ≥ 35 years: Old users	Path-diff	*p* value diff
H6 (+): Costumer Brand Engagement → Continuance Intention	0.113	0.040	3.351	1.120	0.001	0.263	0.073	0.165
H7 (+): Perceived Trust → Continuance Intention	0.176	0.136	5.841	3.415	0.000	0.001	0.040	0.426
H8 (–): Perceived Risk → Continuance Intention	−0.090	−0.028	5.078	1.103	0.000	0.270	0.062	**0.043**
H9 (+): Satisfaction → Continuance Intention	−0.034	−0.042	1.703	1.732	0.089	0.083	0.008	0.806

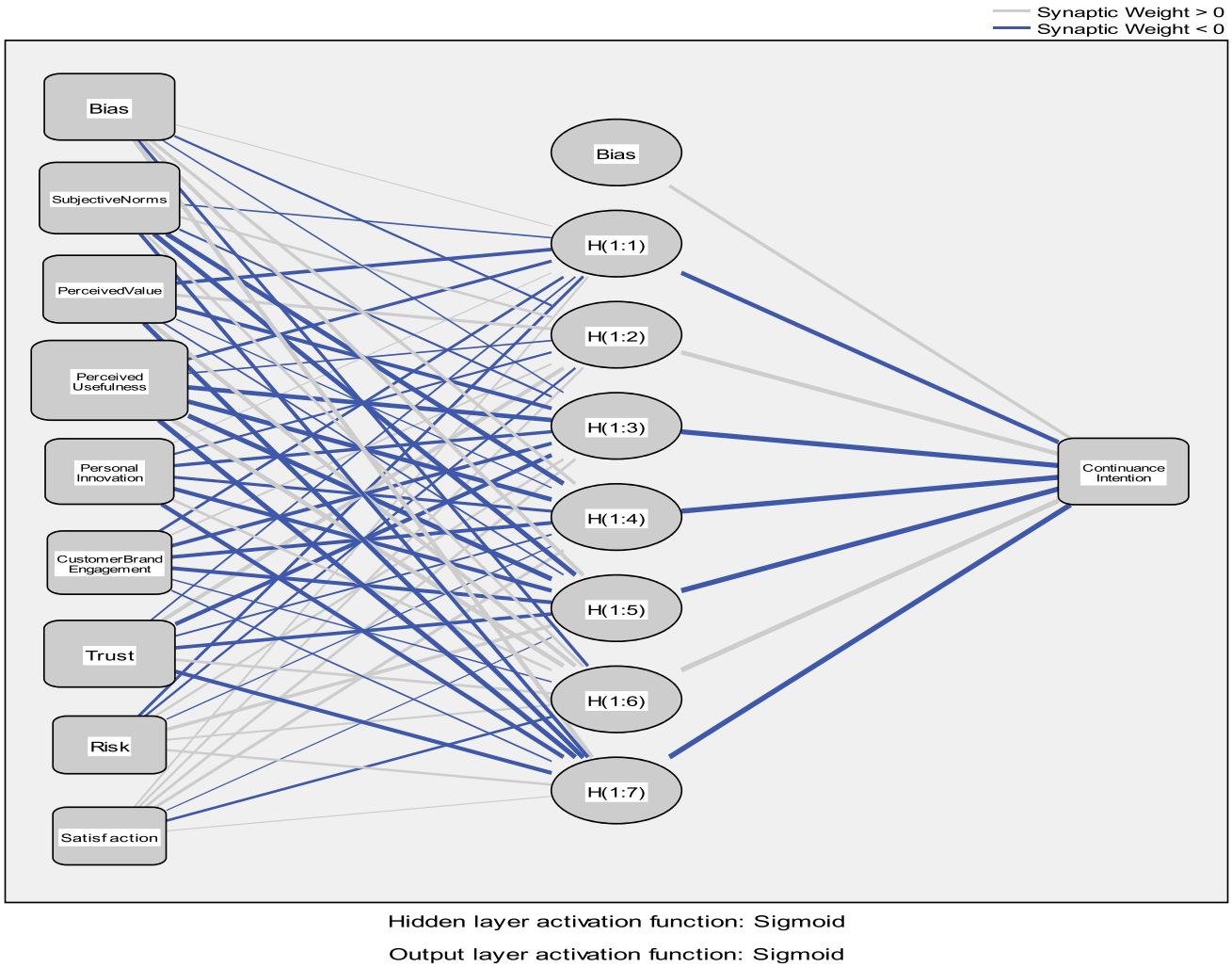

Fig. 2 ANN model

ANN model, we followed the approach suggested by Philips et al. [108] and Leong et al. [68], that is, we calculated the percentage of variance explained (R^2) using the following formula:

$$R^2 = 1 - \frac{RMSE}{s_y^2}$$

Table 10 RMSE values of artificial neural networks

Network	Inputs: SN, PQV, PU, PI, CBE, TR, RISK, SAT Output: CI	
	Training	Testing
1	0.1012	0.1087
2	0.1017	0.1243
3	0.1055	0.0866
4	0.1006	0.1005
5	0.1022	0.0902
6	0.1007	0.1059
7	0.1018	0.1013
8	0.1013	0.1004
9	0.1020	0.0899
10	0.1022	0.0895
Mean	0.1019	0.0997
Standard deviation	0.0014	0.0115

CI continuance intention, *SN* subjective norms, *PQV* performance/quality value, *PU* perceived usefulness, *PI* personal innovation, *CBE* consumer-brand engagement, *TR* perceived trust, *RISK* perceived risk, *SAT* satisfaction

where s_y^2 is the variance of the desired output for the test data [108]. The result shows that 96.3% of the variance in continuance intention is explained by the suggested ANN model.

Finally, a sensitivity analysis was carried out to determine the relative significance of each predictor. The relative significance or importance of every independent variable input measures how much the network output changes with variations in the independent variable [21]. In this sense, normalized importance is the ratio of the importance of each independent variable to the highest importance value [145]. The results of the sensitivity analysis are presented in Table 11.

Generally, the ANN analysis confirmed the findings of the PLS analysis, with minor differences, which may be explained by the higher accuracy of the ANN model and its non-linear nature. The main difference is the finding that PV now has a much stronger influence than that predicted by PLS, surpassing PI, CBE and RISK through the strength of the influence. As confirmed by the ANOVA test of linearity, the relationship between PV and the output CI has significant deviation from linearity. Therefore, the much stronger influence of PV obtained by ANN analysis can be justified by taking into account these non-linear effects in the ANN model in contrast to the PLS-SEM model, which accounts for only the linear parts of relationships. Likewise, other minor differences are a consequence of the fact that the effects of other non-linearities, both significant and insignificant, were taken into account by the ANN model and the fact that, as presented earlier, the non-linear ANN model explains the total variance of CI much better and therefore models the problem more accurately [49]. Although PU is still the strongest predictor, the relative difference between it and the second-strongest predictor, SN, is significantly smaller. Third, in this particular ranking is TR, now followed by PV. Next are PI, CBE, with almost equal influence to PV, then RISK and finally SAT as the least-significant predictor in both analyses.

5 Conclusions and implications

5.1 Summary of the study

The present study aimed to assess the constructs influencing users' continuance intention to use NFC mobile payment technology. To achieve that goal, this research developed

Table 11 Neural network sensitivity analysis

Network	Relative importance							
	SN	PQV	PU	PI	CBE	TR	RISK	SAT
1	0.147	0.119	0.299	0.070	0.053	0.21	0.026	0.074
2	0.160	0.165	0.221	0.133	0.108	0.093	0.113	0.006
3	0.200	0.146	0.238	0.096	0.072	0.070	0.148	0.031
4	0.201	0.113	0.254	0.090	0.118	0.147	0.054	0.023
5	0.173	0.088	0.283	0.103	0.102	0.128	0.082	0.042
6	0.217	0.098	0.287	0.073	0.062	0.124	0.079	0.06
7	0.181	0.132	0.207	0.128	0.129	0.101	0.095	0.026
8	0.202	0.104	0.226	0.104	0.123	0.112	0.077	0.052
9	0.202	0.066	0.287	0.083	0.075	0.125	0.097	0.066
10	0.175	0.139	0.254	0.118	0.097	0.13	0.043	0.044
Average importance	0.192	0.102	0.260	0.100	0.094	0.134	0.073	0.044
Normalized importance (%)	75.1	41.1	100.0	40.1	38.2	51.6	29.6	16.5

SN subjective norms, *PQV* performance/quality value, *PU* perceived usefulness, *PI* personal innovation, *CBE* consumer-brand engagement, *TR* perceived trust, *RISK* perceived risk, *SAT* satisfaction

an empirical model integrating different constructs, namely subjective norms, performance/quality value, perceived usefulness, hedonic motivation, personal innovation, customer brand engagement, risk, trust and satisfaction, to measure users' continuance intention with regard to mobile payment technology. For linear and non-linear relationships, this study adopted structural equation modelling (SEM) to examine the former and an artificial neural network (ANN) analysis to assess the latter.

Firstly, through the use of SEM analysis, this study predicted the relevance of the different variables incorporated into the model; the obtained results reveal that perceived usefulness has the highest influence on users' post-adoption behaviour, followed by subjective norms, increasing their continuance intention to use NFC mobile payment services. Secondly, this research conducted an ANN analysis to enhance the predictive power of the predictors and to obtain detailed results from each of them. A significant deviation from linearity was detected in four examined relationships, which further justified the application of a non-linear technique, such as ANN, which also brings higher prediction accuracy. The superiority of the hybrid approach resulting from combining these two analyses was confirmed by the fact that the ANN model had much higher predictive power as its R^2 (96.3%) was much higher than the R^2 of the SEM-PLS model (72.6%). This study also identified specific valuable components within the context of mobile payments and the continuance intention to use NFC payment systems. A few of these components were derived from the Unified Theory of Acceptance and Use of Technology (UTAUT2) model developed by Venkatesh et al. [141], such as subjective norms, perceived usefulness, hedonic motivation and performance/quality value. These factors can be combined with a few more relevant constructs, such as risk, trust, personal innovation and satisfaction, to measure continuance intention in the context of a developing country. Previous research has already tested UTAUT2 empirically and found it to be superior to other existing technology acceptance models [159]. Recently, UTAUT2 constructs have been used to review acceptance and intention to use with regard to many technology services, such as mobile wallets [129], online education services [102] and other wireless digital systems [74]. The present study can be considered to be new and innovative due to the selection of variables and the methodology applied. In this sense, other studies in the literature have used UTAUT2, but the number of studies assessing new relationships to measure continuance intention in mobile payment technology is rather small.

The present study enhanced the assessment of the factors influencing continuance intention by including personal and behavioural aspects of consumers through subjective norms, personal innovations, performance/quality value, hedonic motivation, trust, satisfaction and brand engagement and incorporating technical aspects of mobile payment technology through perceived usefulness and risk [83]. In this regard, this research contributes to this particular area of knowledge by reviewing the impact of these relevant factors on users' development of post-adoption behaviour towards mobile payments. The study also highlighted the importance of consumer brand engagement and performance/quality value, which are considered to be central to understanding consumer behaviour, even though they have not been discussed in detail in the context of mobile payment services [62, 63]. By including factors such as consumer brand engagement, performance/quality value and satisfaction, this study aimed to reveal consumers' desires and value addition with the purpose of increasing the use of NFC-based mobile payment technology. The results of the study provide payment service providers with major insights to evaluate issues and opportunities while explaining users' post-adoption behaviour and continuance intention.

To ensure that the obtained results are precise and detailed, this study evaluated NFC-based mobile payment services instead of just reviewing mobile payments in general [60]. Moreover, this research fills the existing gap in the extant literature as most studies have been limited to identifying pre-adoption intention, with just a few studies actually bothering to examine users' post-purchase behaviour, which is a key factor in measuring continuance intention in mobile payment technology properly.

5.2 Theoretical implications

One of the most significant theoretical contributions of this research is that it builds on the findings of previous studies on NFC-based mobile payment systems. Many studies in the literature have investigated users' pre-adoption behaviour and intention to use in the context of different developed and developing economies ([128], [145]. However, research on the post-adoption behaviour and continuance intention of mobile payment services through the assessment of unconventional but fundamental variables such as the ones explored in this study is rather scarce.

Likewise, this study contributes to the literature by incorporating a two-step analysis (SEM-ANN) methodology. Through this approach, the study revealed a new perspective with the help of advanced tools to assess the key factors that foster continuance intention in NFC-based mobile payments in the context of Spain. In addition, the SEM-ANN methods incorporated into the study allowed the capturing of both the linear and the non-linear relationships with regard to the independent and dependent variables. Firstly, SEM explored the significance of each determinant of users' continuance intention dependent construct. Secondly, ANN highlighted the impact of the most significant independent variables

through a neural network analysis, which helped to determine the importance of each construct more precisely.

Another main finding from this research is the paramount statistical effect of perceived usefulness followed by subjective norms on the continuance intention to use NFC-based mobile payment technology. These findings are aligned with the previous work of Liébana-Cabanillas et al. [75], which corroborated the capital impact of subjective norms, perceived ease of use and usefulness on users' behavioural intention. The present study took a further step in the assessment of the effect of these variables on users' continuance intention. In a similar study conducted in Taiwan, Hung et al. [54] found subjective norms to be the most significant factor influencing continuance intention in mobile shopping services. Furthermore, the study found a positive effect of performance/quality value and consumer brand engagement on the continuance intention to use NFC-based technology. A few of the other UTAUT2 variables, such as performance/quality value and hedonic motivation, have also been considered in previous studies in the literature to examine the adoption and usage of mobile payment services [73, 75]. These studies encouraged the review of the existing conceptual models while striving to obtain significant findings with regard to mobile payment services. In this sense, Magni et al. [85] developed an empirical model that assessed users' brand engagement and performance/quality value to corroborate their positive influence on behavioural intentions [84, 161]. On the other hand, this study revealed that hedonic motivation has no significant effect on users' continuance intention due to the salient nature of hedonic motivation. In this sense, this type of motivation tends to be missing from the pre- and post-adoption behaviour of an individual, unlike the utilitarian motivation to use a service [101]. The result for hedonic motivation was similar to the findings of Oliveira et al. [102] and Merhi et al. [92], they confirmed that consumers perceive new technology services as beneficial for performing transactions as opposed to giving pleasure and joy. Referring in particular to NFC mobile payments, Morosan and De Franco [96] suggested a very low effect of hedonic pleasure on consumers' intention to use NFC in hotels in the United States. The present study supports the literature.

Finding the dramatic effect of trust and personal innovation on continuance intention is also rather enriching. Yu et al. [155] surveyed 219 mobile payment users in China and found trust and innovation among the few variables affecting their continuance intention to use a service. However, they identified many factors that may have a positive or negative impact on the post-adoption or continuance intention of mobile payment technology. Trust has been reported as one of the most important antecedents of continuance intention in mobile payment technology (2014a, b). Likewise, personal innovation has been found to be relevant in the context of various countries. Thakur and Srivastava [137] enhanced the UTAUT2 model by incorporating users' personal innovation as a driver of mobile payment services in India. In this regard, they found a lack of innovativeness hindering the adoption and usage of mobile payment services in the long term. Slade et al. [130] examined the personal innovativeness of mobile payment users in the USA and found personal innovation to be one of the main antecedents of the technology.

After conducting the SEM analysis, the present study found a negative effect of risk and satisfaction on users' continuance intention regarding NFC-based mobile payment systems. In this sense, Chen and Li [19] performed empirical research on users of NFC-based mobile payment services in China and posited that risk and satisfaction affect continuance intention, a result that is in line with the research by McKnight and Chervany [90] exploring the impact of risk on long-term usage. Another important variable to measure users' continuance intention and usage is satisfaction. In this regard, Flavián et al. [34] found that trust could be measured through users' satisfaction, which in turn affects their continuance intention to use a particular service in the long term. In a similar study, Gao et al. [35] approached 462 mobile payment users through a survey conducted in a developing country, China, to corroborate the relationship between constructs such as security, trust and satisfaction while examining their combined impact on continuance intention in mobile payment services. However, this study differed from previous research in that the results obtained reveal a negative effect of satisfaction on users' continuance intention, supporting the findings by Mohsan et al. [93] in the context of Pakistan. According to them, customer satisfaction is not necessarily always related to customers' intention, leading to retention. According to Reichheld and Aspinall [119], customers who are satisfied with the existing services do not guarantee the continued use of a service or may switch to other better and more useful options. Studies have confirmed a positive (although not perfect) relationship between satisfaction and intention and revealed different incidents when satisfied customers suddenly discontinue their use of a service and switch to other services [7, 43, 93].

The study further explained the moderating effect of gender and age on all the proposed relationships. All the relationships were found to be significant for both men and women except for hedonic motivation and satisfaction in the case of women. The results are consistent with the findings of Passyn et al. [106] and Marinković et al. [87]. Several studies have revealed that both men and women give preference to the usefulness, performance/quality value, trust and subjective norms related to NFC services, which ultimately lead to a positive continuance intention. Hedonic motivation has not been found to be important for either of the groups, supporting the findings of Merhi et al. [92]. Furthermore,

men were found to be more satisfied than women, which affects their continuance intention to use the service [57].

Finally, the study tested the moderating impact of age groups. The study supports the findings of Chawla and Joshi [17] that young users are more inclined to use a technology service due to its usefulness, innovativeness, perceived high trust and subjective norms than old users. The study revealed that old users are concerned about the privacy/risk of a system, and this exerts a negative impact on their continuance intention, supporting previous findings [94, 111]. Meanwhile, young users do not have any such privacy concerns [80]. We found no significance of hedonic motivation and satisfaction on the young and old users' perceptions, supporting previous studies [43, 96].

The results from the PLS analysis were corroborated by the ANN findings; that is, only minor differences were reported. The most important differences are the significantly stronger effect of performance/quality value, which seems logical and falls into line with the findings of Yang et al. [146], and the stronger relative influence of subjective norms as opposed to that of perceived usefulness, supporting the findings of Yadav et al. [145].

Generally speaking, continuance intention regarding a mobile payment service can be explained through these variables, which have rarely been studied in the extant literature [35] and almost negligibly in the context of Spain. Therefore, examining users' continuance intention towards a particular mobile payment service brings new insights and value to the existing body of knowledge on mobile payment adoption.

5.3 Managerial implications

The use of smartphones has dramatically increased in recent years due to many technological innovations at the user and manufacturer levels. NFC systems play a significant role in the context of mobile payment services. NFC-based payments require devices to incorporate a dedicated NFC chip and the appropriate software to handle NFC wireless applications. In recent years, the use of NFC-enabled devices has increased exponentially. In this sense, consumers perceive the usefulness and security of NFC technology in comparison with other mobile payment services, such as SMS or QR codes.

In the context of NFC applications, this research found perceived usefulness and performance/quality value to be significant moderators of continuance intention in NFC payment technology. This indicates that NFC systems should be designed to perform payment tasks. The study recommends that NFC-based mobile payment providers should design a system that is useful and provides performance/quality value to the users while performing a transaction. The system should be convenient, allowing consumers to select and make payments efficiently. Companies should design communication campaigns to target young and innovative professionals, who are inclined to use mobile payment services in the long term, highlighting the features and usefulness of NFC-based payment technology. The present study further determined the decisive effect of users' personal innovation on their continuance intention. In this context, companies can focus on young and innovative consumers who are likely to use the service. Well-informed and innovative customers are more likely to adopt the service; therefore, showcasing the latest features and services through advertising and promotion may positively influence their continuance intention. In fact, obtaining feedback from these consumers and highlighting their suggestions/feedback on social platforms are likely to enhance users' adoption.

To this end, the next important variable was found to be subjective norms. Consumers are highly connected with each other through social platforms and consult reviews and recommendations of others before making a decision. To understand the influence of subjective norms on consumers, companies must review the existing feedback received from societies, families and closed groups that have an influence on users. Companies must target extroverted customers and those who are active on social platforms as they are likely to give genuine feedback to companies about NFC services and their features. Such customers can also be used to convey relevant information about the services in social groups, which may influence the adoption of the system. The lack of effect of hedonic motivation signifies the importance of the task performance and usefulness of a service in comparison with looking for enjoyment and pleasure. Companies must focus on providing convenient and innovative services instead of providing joy to consumers.

In terms of trust and risk, companies should identify what users perceive as threats related to the use of NFC technology. However, it is not possible to ease all the privacy concerns of consumers completely, but payment providers must share the guidelines and steps taken to provide users with secure systems to perform a task. Payment providers should provide details related to end-to-end encryption, data privacy norms, biometric authentication services (i.e., fingerprint readers), sensor-based processes, secured networks and so on to offer a high level of privacy and security to users that is likely to influence their trust. Furthermore, they should make users aware of the threat-proof and secure protocols used in

transactions [102]. This will not only increase the usage but will also make the system more reliable and trustworthy, encouraging users to adopt a long-term continuance intention towards the service.

Finally, customer brand engagement and satisfaction were found to have a smaller and negative effect on users' continuance intention. This confirms that users prefer the service due to its benefits and innovative features, but the use of the NFC system is still lacking in creating brand engagement and satisfaction among the users. In this regard, the study suggests that companies create brand engagement strategies by using loyalty programmes and word-of-mouth marketing and focus more on value creation. Companies should emphasize positive reviews and ask for users' experience that can be shared with others. This will create involvement and intimacy among the customers. In fact, marketing companies must not only focus on the feedback from satisfied customers but also discuss the issues and their shift to a positive experience [102]. To make satisfied customers loyal and enhance their retention, companies must focus on engagement strategies and design a system with new features and services. As a result, consumers' brand engagement with the service will improve as well as their satisfaction and continuance intention.

Lastly, the gender and age gap are narrowing and is significant for the majority of the proposed relationships. This explains why the use of services such as NFC is causing the difference in the factors influencing continuance intention to disappear. The study suggests that companies should focus on similar strategies to target different gender and age groups. Specifically, the study found that women are less satisfied than men with NFC-based payment systems. This needs to be reviewed by companies by collecting live experience feedback and suggesting relevant solutions. In addition, adults were found to be less brand engaged and satisfied with the service. Companies must focus on word-of-mouth marketing and other loyalty programmes to enhance customers' satisfaction and ultimately their adoption.

6 Limitations and avenues for future research

One of the main limitations of the study is the fact that the sample is comprised of users of NFC-based mobile payment services in Spain, aiming to assess their continuance intention through different variables. Future research may include these variables when assessing the context of other countries with diverse cultural and religious backgrounds [43]. A comparative study would reveal the different perspectives and views of users in these countries with regard to NFC-based mobile payment systems. Moreover, a similar study may be conducted on various types of payment systems to understand users' perception and their usage trends for each category of payment systems, namely SMS, QR, mobile banking, mobile wallets and so on [129].

Another limitation of this study is the type of online survey based on a structured questionnaire to determine users' continuance intention towards NFC payment technology at a given moment in time. The authors of the present study recommend that future research on this subject matter should take a longitudinal approach to examining users' pre- and post-adoption behaviour to assess changes in perceptions over time [10].

This research addressed both consumers' psychological factors and technical factors associated with the continued adoption of an NFC-based payment system. In this sense, future research may include a few additional variables to understand users' perceptions further in relation to these new and modern technologies [14]. For example, it would be advisable to examine performance/quality value in detail by including different aspects of the construct (i.e. price value and social value) [28].

Lastly, the authors of this study suggest that future studies take a step further towards the adoption of users' recommendations as a construct to understand the complete life cycle of users in the context of mobile payment systems. Control variables such as the level of studies and income level may also help researchers to understand users' intention on the basis of their different demographic traits.

Appendix 1: Research on m-payment systems

References	Dependent variable	Theory	Country	Independent variables
Al-Amri et al. [3]	Intention to use	None	Malaysia	Perceived ease of use, perceived usefulness, ubiquity, awareness, perceived risk, structural assurance, security, privacy and trust
Ruangkanjanases and Sirikulprasert [117]	Intention to use	IDT TAM	Thailand	Complexity, trust and security, relative advantage, compatibility, social influence and cost
Liébana-Cabanillas et al. (2018)	Intention to use	TAM extended	Spain	Perceived usefulness, perceived ease of use, perceived security, perceived compatibility, subjective norms, personal innovativeness and individual mobility
Museli and Jafari Navimipour [98]	Intention to use	TAM extended	Azerbaijan	Perceived ease of use, potential risk, perceived usefulness and cost
Zhao et al. [149]	Intention to use	TAM extended	United States	Perceived risk, perceived ease of use and perceived usefulness
Ramos de Luna et al. [112]	Intention to use	TAM extended	Spain	Subjective norms, perceived ease of use, perceived usefulness, attitude and perceived security
Christian et al. [27]	Intention to use	TAM extended	Indonesia	E-service Quality, NFC indicators, perceived ease of use and perceived usefulness
Gbongli et al. [36]	Intention to use	TRA IDT TAM UTAUT	Togo	Mobile money self-efficacy, Mobile money technology anxiety, Perceived ease-of-use, perceived usefulness, Attitude and Personal innovativeness
Lee et al. [66]	Intention to use	UTAUT	South Korean	Performance expectancy, Effort expectancy, Social influence, Facilitating conditions and Privacy risk
Chen et al. [18]	Intention to use	SOR	Taiwan	Utilitarian Value, Hedonic Value, Salespersons behaviors and Satisfaction
Lin et al. [79]	Intention to use	UTAUT ISS TTF	China and Korea	Effort expectancy, Facilitating conditions, Information quality, Performance expectancy, Service quality, Social influence, System quality, Task characteristics, Task-technology Fit, Technology characteristics and User satisfaction

References	Dependent variable	Theory	Country	Independent variables
Lu et al. [82]	Continuance Intention	IS continuance theory	China	Social influence, privacy, mobility, privacy protection, mobility, usefulness and satisfaction
Chen and Li [19]	Continuance Intention	IT continuance theory	China	Post perceived usefulness, disconfirmation of pre-perceived usefulness, post perceived risk, disconfirmation of pre-perceived risk, trust and satisfaction
Hossain et al. [50]	Continuance Intention	None	Bangladesh	Perceived usefulness, perceived ease of use, credibility, mobility, perceived risk and satisfaction
Liébana-Cabanillas et al. [74]	Continuance Intention	None	Spain	Convenience, effort expectancy, perceived trust, service quality, social value, satisfaction and perceived risk
Talwar et al. [133]	Continuance Intention	ISS TCE IT continuance theory	India	Initial trust, Perceived information quality, Perceived service quality, Perceived asset specificity, Perceived uncertainty, Confirmation, Perceived usefulness and Dissatisfaction
Wiese and Humbani [143]	Continuance Intention	None	South African	Optimism, Innovativeness, Discomfort, Insecurity, Adoption, Usefulness, Ease of use and Attitude

IDT diffusion of innovations theory, *TAM* technology acceptance model, *TRA* theory of reasoned action, *TPB* theory of planned behavior, *UTAUT* unified theory of acceptance and use of technology, *SOR* stimulus–response model, *TTF* task-technology fit model, *ISS* information systems success model, *TCE* transaction cost economics

Appendix 2: Constructs and measurement items

Construct	Item	Scale
Subjective norms	SN1	The people whose opinions I value would approve of me using NFC mobile payment systems to purchase products
	SN2	Most of the people I have in mind think that I should use NFC mobile payment systems to purchase products
	SN3	They hope that I use NFC mobile payment systems to purchase products
	SN4	The people who are close to me would agree with me using NFC mobile payment systems to purchase products
Performance/quality value	PQV1	NFC mobile payment systems have an acceptable standard of quality
	PQV2	NFC mobile payment systems services make me want to use them
	PQV3	The quality of NFC mobile payment systems is good relative to the price
	PQV4	The fact I use NFC mobile payment systems makes a good impression on other people
Perceived usefulness	PU1	Using NFC mobile payment systems could help me make purchases
	PU2	Using NFC mobile payment systems could increase the efficiency of making my purchases
	PU3	Using NFC mobile payment systems for my purchases could increase my productivity
	PU4	In general, NFC mobile payment systems could be useful for me to make purchases
Hedonic motivation	HM1	Using NFC mobile payment systems is fun
	HM2	Using NFC mobile payment systems is enjoyable
	HM3	Using NFC mobile payment systems is very entertaining
	HM4	Using NFC mobile payment systems gives me pleasure
	HM5	Using NFC mobile payment systems is exciting
Personal innovation	PI1	If I find out about new information technology, I seek ways to experience it
	PI2	I am usually one of the first among my colleagues/peers to explore new information technology
	PI3	In general, I am reluctant to try new information technologies
Consumer-brand engagement	CBE1	I am enthusiastic about NFC mobile payment systems
	CBE2	When I am engaging myself with NFC mobile payment systems, I feel strong and vigorous
	CBE3	I can continue engaging myself with NFC mobile payment systems for very long periods of time
	CBE4	I keep on engaging myself with NFC mobile payment systems, even when things do not go well
	CBE5	The quality of NFC mobile payment systems is high
	CBE6	My expectations with regard to the offer of NFC mobile payment systems are surpassed
	CBE7	The performance of NFC mobile payment systems with regard to other mobile payments is high
Perceived trust	TRUST1	I think that NFC mobile payment systems will keep the promises and commitments they put forward
	TRUST2	NFC mobile payment systems are trustworthy
	TRUST3	I would qualify NFC mobile payment systems as honest
	TRUST4	I think that NFC mobile payment systems are responsible
	TRUST5	In general, I trust NFC mobile payment systems

Construct	Item	Scale
Perceived Risk	PR1	Other people may see the information about my online transactions if I use NFC mobile payment systems
	PR2	There is a high chance of wasting money if I make purchases using NFC mobile payment systems
	PR3	There is significant risk involved in purchasing through NFC mobile payment systems
	PR4	I think that making purchases with NFC mobile payment systems is risky
Satisfaction	SAT1	Disgusted-Pleased
	SAT2	Frustrated-happy/pleased/gratified
	SAT3	Appalling/awful/terrible-delighted/happy
	SAT4	Unsatisfied-satisfied
Continuance intention	CI1	I intend to continue using NFC mobile payment systems in the future
	CI2	I will try to use NFC mobile payment systems in my daily life
	CI3	I will continue to use NFC mobile payment systems as often as I do now

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