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Wearable Technology: a study on the acceptance and use of smartwatches and smart bands

Joana Martins ¹, Bráulio Alturas ^{2*}, Inês Messias ³

¹ Instituto Universitário de Lisboa (ISCTE-IUL), Lisboa, Portugal; ² Instituto Universitário de Lisboa (ISCTE-IUL), ISTAR-Iscte (University Institute of Lisbon), Lisboa, Portugal; ³ Instituto Politécnico de Santarém, ISTAR-Iscte (University Institute of Lisbon), Lisboa, Portugal

Instituto Universitário de Lisboa (ISCTE-IUL), ISTAR-Iscte (University Institute of Lisbon), Av. Forças Armadas, 40, 1649-026 Lisboa, Portugal; Email: braulio.alturas@iscte-iul.pt * corresponding author

Abstract

Wearable devices are increasingly present in our digital society as one of the most promising IoT technologies. This study, using a methodology framework based on a model adapted from UTAUT2, investigates the acceptance of wearable technology and the factors that affect the intention to use and usage behaviour of smartwatches and smart bands in Portugal. Three constructs were added to the original model: Perceived Security, Perceived Privacy, and Brand Name. Considering the methodological framework and the study's goals, quantitative data were collected by questionnaire. 305 valid responses were obtained and analysed using the Smart PLS 4 and IBM SPSS tools. The results of the study confirmed the validity of the model and made it possible to analyse the intention of Portuguese consumers to use smartwatches and smart bands. Results found that the variables Performance expectancy and Habit were the strongest determinants of the Intention to Use smartwatches and smart bands.

Keywords: IoT; Wearable devices; Smartwatches; Smart bands; Technology Acceptance; Structural Model

1 Introduction

The world is evolving at an ever-faster pace, with technology being the main driver of these rapid changes. Considered one of the disruptive technologies of the 21st century, the Internet of Things (IoT) allows various objects to connect to the network, interact with each other, and perform their functions without the necessary intervention and control of those who use them (Lemos, 2013). According to Statista (Vailshery, 2022), by 2030, the number of IoT devices worldwide is expected to triple from 9.7 billion in 2020 to more than 29 billion.

Wearable technology stands out as one of the most promising in the IoT field (Marakhimov and Joo, 2017). From this technology emerge electronic and intelligent devices that can be worn or attached to the human body, capable of connecting to the Internet to obtain and gather information and send data for intelligent decision-making by the user or to connect and interact with other devices, such as smartphones, for computing and communication purposes (John Dian et al., 2020). The miniaturisation and incorporation of technological components currently makes it possible to make and receive calls, messages, use and notifications from emails or social networks, provide value-added, location, and financial payment services, and allows for the real-time monitoring of biometric data (Seneviratne et al., 2017).

In an increasingly digital world, the wearables market is promising, and large-scale growth is expected in the future,

with this market still far from reaching its saturation point (Laricchia, 2022). It's therefore crucial to analyse the level of acceptance and the factors that lead consumers to acquire these devices. Of the existing wearables, we chose to restrict this research to smartwatches and smart bands, as these are the most popular devices (Zhou et al., 2020).

In view of the above, the research question guiding this study is as follows: What factors influence the behavioural intention to use smartwatches and smart bands in Portugal?

The following objectives are defined for this question:

- (1) To investigate the impact of the variables of the UTAUT2 model on the intention to use and the behavioural use of smartwatches and smart bands;
- (2) To analyse the impact of Perceived Security on the intention to use and the behaviour of using smartwatches and smart bands;
- (3) To ascertain the impact of Perceived Privacy on the intention to use and usage behaviour of smartwatches and smart bands;
- (4) To determine the impact of Brand Name on the intention to use and usage behaviour of smartwatches and smart bands.

The remainder of this paper is structured as follows. First, the literature review and conceptual background will be presented. Next, we discuss the research design that was used. This includes our research hypotheses. This is followed by data analysis and a discussion of the results. Lastly, the conclusion summarises the research contributions.

2 Literature review and conceptual background

2.1 Internet of Things to smartwatches and smart bands

Defining IoT is a complex task, and to this day, there is no agreed-upon definition (Atzori et al., 2010).

According to the ITU, IoT can be described as a global infrastructure for the information society, which enables innovative services by interconnecting physical and virtual "things" based on existing and developing interoperable ICTs (ITU, 2012).

Minerva et al. (2015) claim the IoT describes a network of devices, each with built-in sensors, which are connected to the Internet (Minerva et al., 2015).

In the view of Atzori et al. (2010), this is a new paradigm consisting of the presence of smart objects and "things" around us, such as RFID tags, sensors, actuators, smartphones, and smartwatches, which are ready to interact and cooperate to achieve a specific goal (Atzori et al., 2010).

Just as there is no generalised consensus on the definition of IoT, there is no universal list of its domains, only similarities between the opinions of different authors.

Atzori et al. (2010) propose five applications: (i) transport and logistics domain; (ii) health domain; (iii) intelligent environment domain; (iv) personal and social domain; (v) futurism domain.

The European Research Cluster on the IoT (IERC) categorises eight application domains: (i) smart living; (ii) smart health; (iii) smart transport; (iv) smart energy; (v) smart buildings; (vi) smart planet; (vii) smart cities; (viii) smart industries (Vermesan et al., 2014).

More recently, Yang et al. (2017) present a variety of common IoT applications, which include: smart homes, smart cities, smart grids, healthcare equipment, connected vehicles, wearables, industrial automation, and environmental monitoring (Yang et al., 2017).

The indeterminacy of a single definition of IoT, as well as its domains and applications, demonstrates the universality and growth of this technology.

Wearable technology can be considered a subcategory of IoT and stands out as one of the most promising nowadays (Marakhimov and Joo, 2017). Wearables entered the market a few years ago and have already gained their usefulness for several specific functions. They are computational devices whose support and main source of data is the human body. Thus, the different characteristics of the body, such as shape, movement, and temperature, are essential for wearables.

Currently, smartwatches, smart bands, and virtual/augmented reality objects represent the most prominent wearables (Zhou et al., 2020)

Smartwatches combine traditional watches with modern technology. According to Zhou et al. (2020), these devices have three essential functions: as a traditional watch, with the aim of showing the time; as a communication and notification tool between the smartphone and the user, making it possible to make phone calls, view emails, messages or notifications; as a tool for collecting daily data from the user, making it

possible to obtain information on movement, heart rate and sleep status to analyse the user's health (Zhou et al., 2020).

The benefits of smartwatches include the facility to continuously broadcast the user's location, as they have a GPS (Global Positioning System) sensor and permanent contact with the user's skin surface, which makes it possible to identify the person wearing it, measure heart rate, body temperature, and visualise blood oxygen levels, among other indicators (Rawassizadeh et al., 2015). Despite society's sedentary behaviours and resistance to the implementation of a healthy lifestyle, the existing technology favours the use of devices that help promote the user's physical activity (Silva and Alturas, 2021).

However, they have limitations, essentially in terms of their size and autonomy. In terms of size, it is necessary to be careful when using it, since it is a device that is worn on the wrist and therefore should not be too large, so as not to cause discomfort in everyday life, but it should also not be too small since in most smartwatch models it is through the screen, which has the particularity of being tactile, that the user interacts with the equipment and accesses all its features. With regard to autonomy, it can be seen that this is slightly lower than that of larger electronic devices such as smartphones, due to their smaller size, which means that the hardware components tend to have less capacity, and also due to the inclusion of various sensors such as GPS, step counting and Bluetooth, which when in use are responsible for drastically reducing the time the devices can be used (Rawassizadeh et al., 2015).

Smart bands, on the other hand, are seen as watches with specific functions dedicated mainly to a more health-related register.

With a simpler appearance compared to smartwatches, these devices allow you to measure the number of daily steps, distance travelled, heart rate, and quality of sleep, among other indicators. Thus, most Smart bands are equipped with a pedometer, optical heart rate sensor, and other sensors. As a result, all the information can be transmitted to an app that records and analyses the data and, in general, assesses your physical condition and well-being.

Furthermore, they have very affordable and similar prices, allowing you to choose from a wide variety of devices.

Unlike smartwatches, they are comfortable even when exercising and have greater autonomy due to the number of basic functions it performs.

On the other hand, it is a more basic device in general, focusing on health-related activities, while other functions are limited. As for its size, it has small screens that limit the amount of information visible.

As with smartwatches, they may need to be connected to a smartphone to perform most of their functions (Zhou et al., 2020).

2.2 Technology acceptance

Understanding the impact of current technologies on the lives and behaviour of people and organisations serves as a basis for developing new technologies. It is not enough to create

technologies; it is necessary to understand whether they are useful, easy to use, and whether they will be used (Alturas, 2019). Technology acceptance models are therefore developed to understand the factors that influence the adoption of a particular technology.

The UTAUT (Unified Theory of Acceptance and Use of Technology) theorises four constructs that play an important role in behavioural intention to use and actual use behaviour: 1) performance expectancy; 2) effort expectancy; 3) social influence; and 4) facilitating conditions. It is also made up of four moderating constructs: age, gender, individual experience, and voluntariness of use (Venkatesh et al., 2003). The option for this model as the basis of this study is justified by its comprehensive and integrative approach, which incorporates a wide variety of variables based on the main theoretical models developed to explain the technology acceptance and use used (Alturas, 2021). Figure 1 depicts this model.

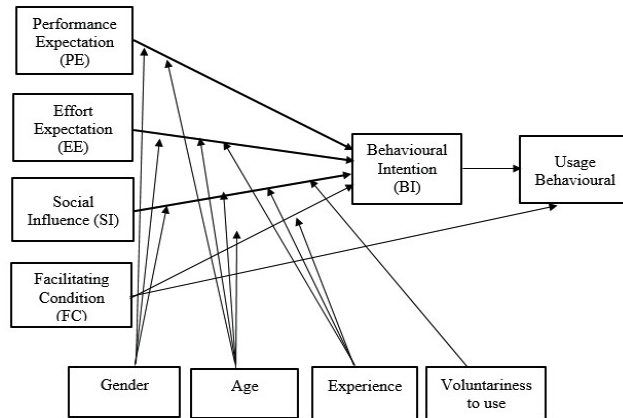


Fig. 1. Unified Theory of Acceptance and Use of Technology (UTAUT)

The performance expectation refers to the degree to which the individual believes that using the technology will help them make gains in terms of their professional performance. Effort expectancy is defined as the degree of ease associated with using the technology. Social influence corresponds to the degree to which the individual is perceived in relation to others in terms of their belief in the need for new technologies to be used or not. And facilitating conditions refer to the degree to which the individual believes that there is an organisational and technical infrastructure to support the use of the system (Parreira et al., 2018; Venkatesh et al., 2003).

A few years later, Venkatesh et al. (2012) published UTAUT2, which is shown in Figure 2. This model is an extension of UTAUT but focuses on the context of consumer use of a system in a non-organisational context, and includes three new constructs: hedonic motivation, price value, and habit (Venkatesh et al., 2012).

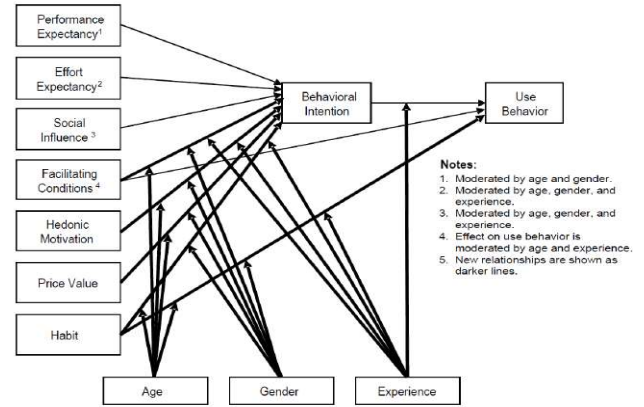


Fig. 2. Unified Theory of Acceptance and Use of Technology 2 (UTAUT2)

Hedonic motivation comprises the fun or pleasure that using a technology can provide. Habit is defined as the extent to which people tend to carry out automatic actions due to learning, initiated after a certain degree of repetition. The price construct was added to the model because an important difference between organisational use and consumer use is that consumers generally bear the monetary cost of using technology, while employees of an organisation don't (Alturas, 2019).

3 Materials and methods

This research was designed with the aim of achieving the study's proposed objectives and consists of two phases.

The first phase consisted of collecting the literature to draw up the theoretical framework, which then enabled to frame the study in the current context and thus perceive its relevance.

The second phase of this research was the design of the questionnaire and its implementation for data collection. To understand which factors influence the behavioural intention to use the wearable devices under study, a model based on UTAUT2 was developed, as this is the model that best explains consumer acceptance and use of a technology (Arenas-Gaitán et al., 2015), but still it was necessary to add indicators specific to the technology under study in this research, that in turn will allow to answer this study's specific goals.

The paradigm of this study is based on a quantitative methodological approach, since the data were gathered by questionnaire, using Likert scales, and hence statistical methods were used to analyse the facts to meet the proposed objectives (Fortin, 1999; Vilelas, 2009).

The universe under study corresponds to the Portuguese population, made up of more than 10 million individuals (10,444,200 in 2022), according to Pordata (INE, 2023). The ideal sample size was estimated by applying the formula proposed by Krejcie and Morgan (1970):

$$n = \frac{X^2 NP(1-P)}{(d^2 (N-1) + X^2 P(1-P))}$$

The parameters used were as follows: Sample number ($n = 10444200$); Confidence level for α equal to 0.05 ($x = 1.96$); Margin of error of 5% ($d = 0.05$).

$$n = \frac{([1,96] \wedge 2 * 10444200 * 0,5(1-0,5)) / ([0,05] \wedge 2 (10444200-1) + [1,96] \wedge 2 * 0,5(1-0,5))}{1}$$

Thus, for this study, the sample should consist of 385 individuals (n=385).

The research model proposed for this study was adapted from the UTAUT2 model (cf Figure 3). Three constructs were added to the original model: Perceived Security, Perceived Privacy, and Brand Name.

To limit the research, the moderating variables, age, gender, and experience, were not included in the model, since this study does not focus on individual differences.

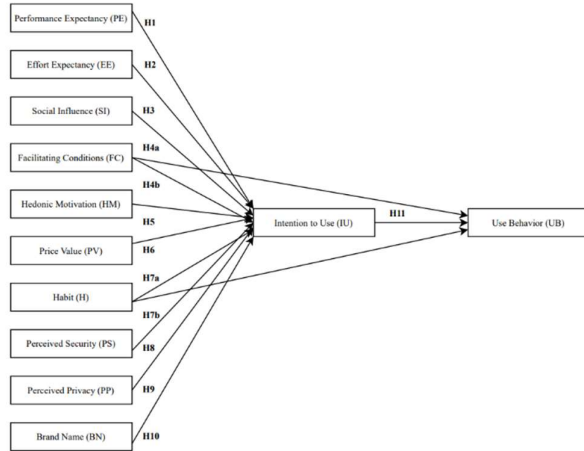


Fig. 3. Proposed research model adapted from the UTAUT2 model

Performance Expectancy (PE): Performance expectancy refers to an individual's perception of the improvement and benefits that the use of a system or technology will bring to the performance of their work or tasks (Gao and Bai, 2014; Venkatesh et al., 2003, 2012). It can also be referred to as perceived usefulness, where the user believes that using the technology will give them additional value that they wouldn't normally get if they didn't use that technology (Gao and Bai, 2014). Performance expectations have been identified as the main determining factor for the acceptance and use of new technologies, such as wearable devices, according to studies on the acceptance of this technology in various domains (Binyamin and Hoque, 2020; Larnyo et al., 2020; Venkatesh et al., 2012). The following research hypothesis was therefore formulated:

H1: Performance expectations positively affect the intention to use smartwatches and smart bands.

Effort Expectancy (EE): Based on the study carried out by Venkatesh et al. (2012), effort expectancy corresponds to the level of ease associated with using a particular system or technology. Research by Gao and Bai (2014) and Lee et al. (2012) indicates that the ease of use of a device played a significant role in determining a user's adoption of technology. On the other hand, studies carried out in Saudi Arabia (Binyamin and Hoque, 2020) and South Africa (Rubin and Ophoff, 2018) show that the expectation of effort did not influence the intention to use wearable devices. The following research hypothesis was therefore formulated:

H2: Effort expectancy positively affects the intention to use smartwatches and smart bands.

Social Influence (SI): Social influence can be defined as an individual's perception that the people most relevant to them, such as family and friends, believe that they should use a particular system or technology. It can be measured by the importance an individual gives to the approval and opinion of others about the use of a particular technology (Venkatesh et al., 2003, 2012). Several studies have demonstrated the great impact of Social Influence on a user's intention to adopt a new technology (Binyamin and Hoque, 2020; Wang et al., 2020). Some studies, however, have found no significant effect on the intention to use wearable devices (Beh et al., 2019; Rubin and Ophoff, 2018), likewise, a study in Asia has shown that social influence has no impact on the intention to adopt IoT (Pal et al., 2018). The following research hypothesis was therefore formulated:

H3: Social influence positively affects the intention to use smartwatches and smart bands.

Facilitating Conditions (FC): Facilitating conditions are defined as the perceived existence of an organisational and technical structure to support the use of technology (Venkatesh et al., 2003, 2012). They reflect the effect of a user's knowledge, skill, and resources (Venkatesh et al., 2003). Research by Venkatesh et al. (2012) and Beh et al. (2019) indicates that there is a positive relationship between enabling conditions and the adoption of a technology, because an individual is more likely to use a certain type of technology if they have more access to resources and support for that technology. The following research hypotheses were therefore formulated:

H4a: Facilitating conditions positively affect the intention to use smartwatches and smart bands.

H4b: Facilitating conditions positively affect the behaviour of using smartwatches and smart bands.

Hedonic Motivation (HM): Hedonic motivation refers to the degree of enjoyment and pleasure that the individual feels when adopting a new technology (Venkatesh et al., 2012). Hedonic motivation is correlated with the intrinsic nature of the individual, which can be aroused by personal characteristics or cognitive states (Magni et al., 2010). Previous studies related to wearable technology establish a positive relationship between hedonic motivation and behavioural intention (Beh et al., 2019; Gao et al., 2015). Analysing an individual's intrinsic perception of technological innovation is necessary regarding consumer-rated devices, as consumers do not only focus on the utilitarian aspects, but also consider the hedonic aspects of using technology. This study suggests that if the individual can derive a sense of pleasure from using a smartwatch and smart band through their functions and features, they will be intrinsically motivated to accept and use these devices. The following research hypothesis was therefore formulated:

H5: Hedonic motivation positively affects the intention to use smartwatches and smart bands.

Price Value (PV): In contrast to organisational contexts, the financial cost of using new technologies is borne by consumers. Thus, before making the decision to use the new technology, an individual cognitively compares the benefits they will obtain with the financial cost that must be sacrificed.

Price value has a positive effect on behavioural intention if an individual perceives that the advantages offered by using the technology outweigh the monetary cost (Venkatesh et al., 2012). However, in the context of wearable technology, Beh et al. (2019) and Kim and Shin (2015) demonstrated the insignificant effects of perceived cost on consumers' intention to use this type of device, contradicting the study by Venkatesh et al. (2012). Nevertheless, the following research hypothesis was formulated:

H6: Price value positively affects the intention to use smartwatches and smart bands.

Habit (H): Habit was identified by Venkatesh et al. (2012) as the degree to which consumers automatically use technology in the learning process, based on prior knowledge. The authors state that the repetition of a single action causes an individual to have ingrained intentions that, in turn, determine the technology an individual adopts. The greater the ability to develop a habit, the greater the chances of adopting a technology (Venkatesh et al., 2012). As with the previous constructs, Venkatesh et al. (2012) validated habit as an explanatory factor for both the intention to use and the actual use of technology in consumer environments. On the other hand, a study conducted in Bangladesh on wearable devices concluded that habit has no significant influence on behavioural intention (Rahman et al., 2022). The following research hypotheses were therefore formulated:

H7a: Habit positively affects the intention to use smartwatches and smart bands.

H7b: Habit positively affects the behaviour of using smartwatches and smart bands.

Perceived Security (PS): According to Shin (2010), Perceived Security is defined by the extent to which an individual believes that using a particular technology is risk-free and safe. It is based on a consumer's subjective beliefs, and these safety beliefs control the decision to accept or not accept a technology (McMillan, 2018). Research by Salisbury et al. (2001) and Shin (2010) confirmed the effect of perceived security on individuals' behavioural intentions. This new construct is proposed to help us understand how perceptions regarding the security of data collected by these devices can influence buyers in Portugal, in the current context, where data security is both a concern and a right protected by law.

The following research hypothesis was therefore formulated:

H8: Perceived security positively affects the intention to use smartwatches and smart bands.

Perceived Privacy (PP): According to Xue (2019), privacy issues are a topic of concern for consumers of

wearables. Consumers are reluctant to enter their personal information when requested because they are concerned about the ability of devices to detect, collect, and store data that is often private, confidential, or sensitive, and that it will be used in an unauthorised way or disclosed to third parties (Motti and Caine, 2015). However, compared to other smart devices such as smartphones, people still show a relatively low risk perception when it comes to privacy issues (Lee et al., 2018). Perceived privacy is defined by Malhotra et al. (2004) as the concern people have about their loss of information privacy. This new construct is proposed to help us understand how perceptions regarding the privacy of data collected by these devices can influence consumers in Portugal, in the current context, where the right to privacy is both a concern and a right protected by law.

The following research hypothesis was therefore formulated:

H9: Perceived privacy positively affects the intention to use smartwatches and smart bands.

Brand Name (BN): The brand name assumes a preponderant role in consumer choices in circumstances involving uncertainty about them (Erdem and Keane, 1996). Furthermore, the brand name is a crucial determinant of the success of a new product or service. When consumers have no experience with a product or service, previous experience with well-known brand names offers them a certain degree of familiarity (Grewal et al., 1998). For Lau and Lee (1999) Lau & Lee (1999), trust in the brand name is an essential element in the development of brand loyalty. Therefore, the brand name has been the subject of research into consumer choice of products or services (Brucks et al., 2000). In the context of the technology under study, Muller and Klerk (2020) validated the brand name as an explanatory factor in the intention to use wearables. This new construct is proposed because, in the Portuguese context as well, the brand can be an important social factor in the purchasing decision, often associated with the product's quality and durability.

The following research hypothesis was therefore formulated:

H10: Brand name positively affects the intention to use smartwatches and smart bands.

Intention to Use (IU): Intention to use precedes the use behaviour construct and functions as the main predictor of technology use behaviour in UTAUT (Venkatesh et al., 2012). According to Davis et al. (1989), behavioural intention is the strongest indication of use. If an individual has the intention to use a certain technology, they are more likely to use that technology. Venkatesh et al. (2012) state that intention to use UTAUT has a direct positive effect on technology use behaviour. In the context of this research, intention to use refers to the intention of Portuguese consumers to use and continue to use smartwatches and smart bands. The following research hypothesis was therefore formulated:

H11: Intention to use positively affects the behaviour of using smartwatches and smart bands.

The questionnaire was administered over two weeks, between 10/09/2023 and 25/09/2023, through social media.

The questionnaire was designed based on the operationalisation of the constructs.

In the presentation phase, it indicated the intended study along with information regarding the anonymity of the answers collected from the respondents, together with the respondents' informed consent.

As for the first group, relating to the respondent's profile, the information collected focused on gender, age, academic background, and monthly household income, and aimed to understand whether the respondent had any knowledge of wearable technology.

The second group consisted of 42 items corresponding to 12 constructs: 1) Performance Expectancy, 2) Effort Expectancy, 3) Social Influence, 4) Facilitating Conditions, 5) Hedonic Motivation, 6) Price Value, 7) Habit, 8) Perceived Safety, 9) Perceived Privacy, 10) Brand Name, 11) Intention to Use, and 12) Use Behaviour. The items for each construct were duly adapted from existing literature, with its validity and reliability tested as presented in the following chapter. The items were based on a 5-point Likert scale, where the number 1 represents "Strongly Disagree", and the number 5 represents "Strongly Agree".

To ensure that the questionnaire would be understandable to its respondents, it was initially pre-tested and reviewed by nine people.

The answers to the online questionnaire were collected directly into an Excel database. The data was statistically processed using the following programmes: IBM SPSS Statistics 28 and SmartPLS 4.

4 Results

4.1 Demographic profile

The sample for this study was obtained through an online questionnaire and included 305 individuals. Given that the sample size calculation indicated a need for 385 responses, this means that the sample in this study may not be statistically representative of the Portuguese population. Nevertheless, the sample size was sufficient to perform PLS-SEM analysis. Based on the studies presented by Cohen (1988) and Westland (2010), the minimum sample size for PLS-SEM analysis was calculated as proposed by Soper (2026). Thus, the expected effect size was set at 0.3, the number of latent variables at 2, the number of observable variables at 10, the p-value at 0.05, and the statistical power at 0.8, resulting in a minimum sample size of 90 for effect size detection and 100 for PLS-SEM analysis. This calculation allowed us to proceed with the study using a PLS-SEM analysis, as the number of respondents is three times the minimum required number.

Most of the participants (52.8%) were females, while the remaining participants were male (47.2%).

About the age, the study participants were aged between 18 and 65, with the average age being 29.34, the mode 23,

and the median 25. As a result, most of the people who answered this questionnaire were young adults.

Regarding the distribution of participants by academic background, most respondents went on to university education, since 60% have a bachelor's degree, 29.5% have a master's degree, 3% have a postgraduate degree, and 0.7% have a doctorate degree. In a lesser number, 6.9% of respondents had a high school degree.

Regarding the monthly income earned by the household, 35.4% of the participants have an income of 1000€-1499€, 21.3% have an income of over 2500€, and 19% have an income of between 1500€-1999€. On the other hand, 14.4% of respondents have an income of between €2000-€2499. Only 3% have an income between 760€-999€.

To gauge whether respondents were aware of wearable technology, a question was added for this purpose. Of the total sample, most respondents (99%) were aware of the technology under study, with only 3 participants saying they were unaware of it.

4.2 Analysis of main results

Using the SmartPLS 4 programme, the structural equation modelling technique based on partial least squares (PLS-SEM) was used to represent the research model to test the hypotheses and answer the objectives of this study. The analysis of the research model was divided into two parts: the analysis of the Measurement Model, where the reflective and formative constructs of the model were assessed, and the validation of the Structural Model (Hair et al., 2014).

Analysis of the Measurement Model

To evaluate the measurement model, it's necessary to analyse the reliability and validity of the reflective constructs and the collinearity and statistical significance of the indicators of the model's formative construct.

When analysing the reflective constructs, the reliability and validity indicators (convergent and discriminant) were examined (Fauzi, 2022).

One of the most widely used techniques for testing the reliability of internal consistency is Cronbach's alpha. This varies between 0 and 1, with values above 0.7 being considered good (Henseler et al., 2009).

According to Hair et al. (2014), due to its limitations, Cronbach's Alpha can be used as a conservative measure of internal consistency reliability, with Composite Reliability being a more appropriate measure. Values above 0.7 are considered good values to guarantee good reliability (Hair et al., 2011).

The results presented in Table 1 show that all the variables have Cronbach's Alpha and Composite Reliability values above the reference values, thus demonstrating the internal consistency of the measures used in this study.

It must also be ensured that the Outer Loading values of each indicator and its construct are greater than 0.7. If this criterion is not met, if the Outer Loading value is less than 0.4, it should be eliminated from the model. For Outer Loading values between 0.4 and 0.7, the impact of eliminating the item on the Average Extracted Variance

(AVE) and Composite Reliability indicators should be assessed, and it is only desirable to effectively eliminate the item when the values of these indicators improve (Hair et al., 2014). In this case, only item SP4 was eliminated from the model because it had an Outer Loading of less than 0.4.

Table 1. Cronbach's Alpha, Composite Reliability, and AVE.

	Cronbach's alpha	Composite Reliability	Average Variance Extracted (AVE)
Facilitating Conditions (FC)	0.729	0.777	0.542
Performance Expectancy (PE)	0.947	0.948	0.864
Effort Expectancy (EE)	0.869	0.868	0.796
Habit (H)	0.960	0.966	0.893
Social Influence (SI)	0.858	0.873	0.642
Intention to Use (IU)	0.985	0.985	0.971
Hedonic Motivation (HM)	0.772	0.778	0.685
Brand Name (BN)	0.894	0.906	0.824
Perceived Privacy (PP)	0.768	0.829	0.685
Perceived Security (PS)	0.942	0.947	0.852
Price Value (PV)	0.785	0.844	0.701

The second step in the assessment of reflective indicators is the assessment of validity (Hair et al., 2014).

Convergent validity measures the extent to which a construct converges in its indicators, explaining the variation in its items. To assess convergent validity, we analysed the AVE indicator, whose value must be equal to or greater than 0.5 to guarantee convergent validity (Hair et al., 2011). As can be seen in Table 1, the AVE values are well above the minimum threshold of 0.5, which indicates that, on average, each construct explains more than 50% of the variance of its items (Hair et al., 2019).

Following the reliability validation of convergent validation, discriminant validation follows. Discriminant validity represents the degree to which the construct is empirically distinct from other constructs or, in other words, the construct measures what it is intended to measure (Hair et al., 2014).

To this end, three criteria were analysed: the Fornell-Larcker criterion, the Cross Loadings, and the Heterotrait-monotrait ratio of correlations (HTMT) criterion.

Table 2 shows that the square roots of the AVE (on the main diagonal) are higher than the correlations between the

remaining concepts (remaining elements in the corresponding row and column), i.e., considering the Fornell-Larcker criterion, the existence of discriminant validity is suggested (Hair et al., 2014).

Table 2. Fornell-Larcker criterion

	FC	PE	EE	H	SI	IU	HM	BN	PP	PS	PV
FC	0.736										
PE	0.487	0.929									
EE	0.577	0.628	0.892								
H	0.522	0.836	0.584	0.945							
SI	0.390	0.591	0.368	0.553	0.801						
IU	0.512	0.801	0.557	0.852	0.563	0.985					
HM	0.327	0.510	0.345	0.485	0.342	0.452	0.828				
BN	0.316	0.231	0.235	0.299	0.137	0.315	0.219	0.908			
PP	-0.426	-0.497	-0.537	-0.563	-0.347	-0.598	-0.271	-0.330	0.828		
PS	0.556	0.585	0.547	0.602	0.525	0.645	0.380	0.264	-0.647	0.923	
PV	0.385	0.492	0.332	0.517	0.389	0.553	0.402	0.214	-0.378	0.495	0.837

Looking at Table 3, and considering the HTMT criterion, which represents the average correlation of indicators between constructs measuring different phenomena in relation to the average correlation of indicators measuring the same construct, values too close to 1 indicate a lack of discriminant validity, with 0.9 suggested as the threshold value if the model contains relatively similar concepts conceptually (Henseler et al., 2015). In this case, it is possible to affirm the existence of discriminant validity, since all the values presented are lower than 0.9, as seen in Table 3.

Table 3. HTMT criterion

	FC	PE	EE	H	SI	IU	HM	BN	PP	PS	PV
FC											
PE	0.534										
EE	0.668	0.691									
H	0.576	0.878	0.636								
SI	0.479	0.645	0.416	0.604							
IU	0.560	0.829	0.601	0.874	0.600						
HM	0.415	0.587	0.419	0.559	0.401	0.510					
BN	0.375	0.247	0.263	0.314	0.148	0.332	0.258				
PP	0.497	0.570	0.649	0.634	0.390	0.671	0.334	0.391			
PS	0.632	0.617	0.602	0.631	0.577	0.667	0.437	0.285	0.724		
PV	0.483	0.561	0.388	0.587	0.467	0.613	0.519	0.249	0.462	0.571	

After evaluating the reflective constructs, we proceeded to evaluate the only formative construct in this model, which concerns Use Behaviour. This requires analysing the collinearity and statistical significance of the indicators (Sarstedt et al., 2021).

To assess the level of collinearity between the training indicators, the VIF (Variance Inflation Factor) associated with each item was used. The VIF measures the degree to which each independent variable in a multiple regression is explained by the other independent variables associated with the construct (Hair et al., 2014). A higher VIF implies a higher level of collinearity, so VIFs above 5 are indicative of a potential collinearity problem (Sarstedt et al., 2021).

It should be noted that the items CU1 and CU2 have a VIF greater than 0.2 and less than 5, which means that there are no collinearity problems. Analysing statistical significance, at a 5% significance level, items CU1 and CU2 are statistically significant, since they have values of less than 0.05.

4.3 Validation of the Structural Model

To evaluate the quality of the structural model, the collinearity, coefficients of determination $[(R)^2]$, path coefficients, and effect size (f^2) were analysed.

To assess collinearity, the VIF values are once again checked. As mentioned above, VIF values above 5 indicate collinearity between the indicators, and, as can be seen from Tables 4 and 5, there are no collinearity problems.

Table 4. Collinearity of Intention to Use

	Intention to Use
	VIF
Facilitating Conditions	1.823
Performance Expectancy	4.182
Effort Expectancy	2.160
Habit	3.963
Social Influence	1.711
Hedonic Motivation	1.442
Brand Name	1.200
Perceived Privacy	2.060
Perceived Security	2.518
Price Value	1.544

Table 5. Collinearity of Use Behaviour

	Use Behaviour
	VIF
Facilitating Conditions	1.398
Habit	3.802
Intention to Use	3.753

According to Sarstedt et al. (2021), the coefficient of determination $[(R)^2]$ is a measure of the model's predictive accuracy that varies between 0 and 1, where higher values indicate a greater degree of predictive accuracy. R^2 values of 0.75, 0.5, and 0.25 are considered substantial, moderate, and weak, respectively. Looking at the R^2 values (coefficient of determination), we can see that Intention to Use has a substantial value (0.788) and Use Behaviour has a moderate value (0.678).

The path coefficients refer to the hypothetical relationships linking the constructs. Evaluating the path coefficients in terms of significance produced the results illustrated in Table 6.

Table 6. Path coefficients and p-values

	Path Coefficient	P-value	Result
H1: Performance Expectancy → Intention to Use	0.244	0.000	Supported
H2: Effort Expectancy → Intention to Use	-0.038	0.366	Not supported
H3: Social Influence → Intention to Use	0.048	0.248	Not supported
H4a: Facilitating Conditions → Intention to Use	0.014	0.637	Not supported
H4b: Facilitating Conditions → Use Behaviour	0.096	0.014	Supported
H5: Hedonic Motivation → Intention to Use	-0.018	0.602	Not supported
H6: Price Value → Intention to Use	0.091	0.015	Supported
H7a: Habit → Intention to Use	0.474	0.000	Supported
H7b: Habit → Use Behaviour	0.403	0.000	Supported
H8: Perceived Security → Intention to Use	0.084	0.071	Not supported
H9: Perceived Privacy → Intention to Use	0.111	0.005	Supported
H10: Brand Name → Intention to Use	0.040	0.135	Not supported
H11: Intention to Use → Use Behaviour	0.395	0.000	Supported

Hypotheses H1, H4b, H6, H7a, H7b, H9, and H11 were confirmed at a 5% significance level. Of the three new constructs added to the UTAUT2 model, only Perceived Privacy proved to be significant.

The effect size analysis (f^2) is carried out to assess the change in the R^2 value when an exogenous construct is eliminated from the model. The f^2 is interpreted using the values 0.02, 0.15, and 0.35 as a reference, with the effect being small, medium, and large, respectively (Hair et al., 2014).

Tables 7 and 8 show that all the variables had a small effect on both Intention to Use and Use Behaviour, apart from Habit, which represents the highest value, with a medium effect in relation to Intention to Use.

Table 7. Effect size on Intention to Use

	Intention to Use
	f^2
Performance Expectancy	0.067
Habit	0.267
Perceived Privacy	0.028
Price Value	0.025

Table 8. Effect size on Use Behaviour

	Use Behaviour
	f^2
Facilitating Conditions	0.021
Habit	0.133
Intention to Use	0.129

5 Discussion

The model studied explained 67.8% of Usage Behaviour and 78.8% of Usage Intention, which represented a very satisfactory predictive value.

Performance Expectancy was determined to be one of the most important for this study, as it made a statistically significant contribution to Intention to Use. The relationship between Performance Expectancy - Intention to Use produced a p-value of 0.000. This result suggests that individuals who understand the benefits provided by

smartwatches and smart bands as a relevant factor are more likely to acquire and use them. The results of this research are consistent with previous studies (Adapa et al., 2018; Talukder et al., 2019) related to wearable technology, in that Performance Expectancy is also a significant factor for behavioural intention towards wearables.

Effort Expectancy didn't have a statistically significant effect on Intention to Use in this study, since the relationship Effort Expectancy - Intention to Use generated a p-value of 0.366. According to other research (Adapa et al., 2018; Gao and Bai, 2014; Talukder et al., 2019), Effort Expectancy is a significant factor for the adoption of wearable devices, which contradicts the results of the present study, given that Effort Expectancy was considered an unimportant factor for the intention to use smartwatches and smart bands. This result suggests that individuals are open to learning how to use wearable devices because of the practicality they will add to their daily lives, even if they are complex devices. However, nowadays consumers are finding it easier to adapt to new technologies, as daily contact with electronic devices such as computers and smartphones is commonplace, something that will be reflected in the Effort Expectancy construct, which is no longer a relevant factor in the intention to use. The fact that the respondents have not had contact with or used a smartwatch or smart band may also explain this result. This construct will only be important once consumers have tried out a device.

Other studies (Binyamin and Hoque, 2020; Venkatesh et al., 2012; Wang et al., 2020) have proven that Social Influence is an important factor in using a new technology, since it contributed significantly to Behavioural Intention. The results of this research suggest the opposite since the relationship Social Influence - Intention to Use produced a p-value of 0.248. This implies that the opinions of members of consumers' immediate social circle, such as family and friends, have no influence on their intention to use the wearable under study. A possible explanation for the insignificance of the social influence found in this study may be related to the fact that some of the respondents are early adopters of new technologies and don't need opinions from their social groups, since they themselves are the influential people for other potential adopters. Consumers who use new products before most people tend to be younger individuals with a higher level of education (Läpple and Rensburg, 2011), like most respondents in this research.

Although the Facilitating Conditions construct was validated in the original model (UTAUT2) as a predictor of Intention to Use (Venkatesh et al., 2012), in this study, it was not statistically significant, given that the relationship between Facilitating Conditions - Intention to Use produced a p-value of 0.637. However, the same construct was validated as a predictor of Use Behaviour because the relationship between Facilitating Conditions - Use Behaviour obtained a p-value of 0.014. The facilitating conditions in this study reflect the effect of the necessary resources, Internet connectivity, and compatibility with other smart devices, such as smartphones, the knowledge required to use the devices, and help from third parties, should the user need it.

The results obtained suggest that consumers' perceptions of the resources and support available have no influence on the intention to adopt, but do have an influence on actual use.

The results determined that Hedonic Motivation is an insignificant factor for Intention to Use, since the relationship between Hedonic Motivation - Intention to Use generated a p-value of 0.602. The results of this study suggest that users of smartwatches and smart bands are not enjoying their experiences when using these devices, which is reinforced in the research conducted by Patel and O'Kane (2015), who explain that users are distracted during their exercise routine. Thus, it's possible to infer that consumers who do not associate pleasure and fun with the use of smartwatches and smart bands will not intend to use them.

As for Price Value, this is considered an important factor in explaining Intention to Use, so it proved to be statistically significant, as the relationship between Price Value - Intention to Use produced a p-value of 0.015. This result suggests that before making the decision to use the new technology, an individual cognitively compares the benefits they will obtain with the financial cost they will have to sacrifice. Along these lines, the individual who understands that the advantages of using a smartwatch and smart band are greater than the monetary cost paid to use this technology is more likely to use and acquire these devices.

Habit is one of the strongest determinants of Intention to Use alongside Performance Expectancy and is also the strongest determinant of Use Behaviour for smartwatches and smart bands, with a statistically significant p-value of 0.000, in line with other research (Talukder et al., 2019; Venkatesh et al., 2012). According to Venkatesh et al. (2012), the greater the ability to create a habit, the greater the chances of adopting a technology. In this case, consumers who develop the habit of using smartwatches and smart bands will not only intend to use these devices but will also continue to use them effectively.

Although it made sense to incorporate the Perceived Security construct into the model, since this variable has been shown in studies to have a significant effect on individuals' behavioural intentions (Salisbury et al., 2001; Shin, 2010), the hypothesis that Perceived Security positively affects Intention to Use smartwatches and smart bands was not confirmed, so the relationship Perceived Safety - Intention to Use generated a p-value of 0.071. Therefore, the results of this research suggest that consumers who participated in this study did not consider security issues when using these devices. Miguel (2023) also notes that, in his study, perceived safety did not have a statistically significant effect on the intention to use. Alves (2023) in his study found that perceived risks were not statistically significant on continued intentions, leading him to infer that awareness of risks might not be enough to deter people from using these devices, especially if perceived benefits are viewed as more valuable. It might be that the perception of the benefits of using wearable technology outweighs the perceived risks.

On the other hand, this study's findings show that there is concern about privacy issues when adopting smartwatches and smart bands, since in this study, Perceived Privacy

proved to be statistically significant, as the relationship between Perceived Privacy - Intention to Use produced a p-value of 0.005. Consumers could be beginning to realise the dangers inherent in the use of wearable devices and give the same importance to privacy issues as smartwatches and smart bands, compared to other smart devices. Alves (2016) also suggests in a previous study that respondents did not view privacy as a concern, although that study indicated that perceived security influenced behavioural intent.

Brand Name didn't prove to be a relevant factor in Intention to Use, since the relationship between Brand Name - Intention to Use produced a p-value of 0.135. Also Alves (2016) had similar results, stating that this was not a relevant factor that would impact Intent to Use. Considering that smartwatches and smart bands have been on the Portuguese market for a long time and are already known by most of the respondents, it can be concluded that the brand name isn't a preponderant factor in choosing these wearables in circumstances involving uncertainty about them.

Finally, the influence of Intention to Use on Usage Behaviour was statistically significant, since the relationship between Intention to Use - Usage Behaviour generated a p-value of 0.000. This result reveals that an individual who intends to use a smartwatch or smart band is more likely to do so.

6 Conclusion

The focus of this research was on analysing the acceptance of smartwatches and smart bands by Portuguese consumers, as well as understanding the factors that lead to the intention to use and, consequently, the behaviour of using these devices.

Based on the literature review, it was decided that the model to be adopted would be the UTAUT2, and, to this end, a questionnaire was applied. Three constructs were added to the original UTAUT2 model: Perceived Security, Perceived Privacy, and Brand Name.

The variables Performance Expectancy and Habit were the strongest determinants of Intention to Use smartwatches and smart bands, and the variables Habit and Intention to Use were the strongest determinants in explaining the Usage Behaviour of the wearable devices under study. In addition, Price Value also proved to be a determinant of Intention to Use and Facilitating Conditions of Use Behaviour.

Perceived Safety had no impact on Intention and Behaviour to Use smartwatches and smart bands, and therefore, this might suggest that Portuguese consumers have not yet concerns about the safety of these devices.

Privacy issues, on the other hand, seem to raise some level of concern among respondents. Consequently, Perceived Privacy has an influence on Intention to Use and Use Behaviour of smartwatches and smart bands.

This research has shown that the Brand Name had no impact on Intention to Use and, consequently, Use Behaviour. Thus, the Brand Name might not be a preponderant factor in the choice of smartwatches and smart bands in circumstances involving uncertainty about them, nor is it a novelty, since a large part of the population is already

aware of this type of device, and they have already been on the market in Portugal for some years.

The limitations of this study are related to the method used to collect data, the sample size, and the moderating variables of the UTAUT2 model. As the data collection method was a questionnaire, in this case a closed-ended questionnaire, it limits the respondents' opinion, as it doesn't allow them to have an informed opinion on the subject in question. For future studies, it would be interesting to carry out research using a qualitative methodology. Given that the questionnaire was distributed via social media, this study employed a non-probabilistic convenience sampling method; therefore, it cannot be said to be representative of the Portuguese population in all its diverse socioeconomic contexts. The fact that the sample was not sufficiently representative of the Portuguese population is another limitation of the study. Therefore, future studies could be based on a larger sample.

Another limitation of this study is that the moderating variables of the UTAUT2 model were not considered. They could therefore be included in future research, given their significant effect both on the original UTAUT2 model and on studies related to wearable technology.

Although the results of this study suggest that not all constructs proposed in this model influence the intention to use wearable devices, and although there are considerable limitations given the sample size and data collection method, the results presented here are relevant to the context of the wearable device market in Portugal, as they suggest that there are concerns regarding the privacy of user data. Considering the use of these devices in medical contexts, where sensitive data is shared, further, more in-depth studies are suggested to overcome the limitations of this study and investigate possible implications for the intention and continued use of these devices.

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Declarations

Conflict of interest: The authors declare no conflict of interest.

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