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INTENÇÃO DE USAR SOLUÇÕES DE MICROMOBILIDADE ELÉTRICA – ESTUDO DOS SISTEMAS DE PARTILHA DE TROTINETES ELÉTRICAS

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Intention to use electric micromobility solutions – Insights from E-scooter sharing in Coimbra

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“I know the price of success: dedication, hard work, and an unremitting devotion to the things you want to see happen.”

Frank Lloyd Wright

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Resumo

Nos últimos anos, a micromobilidade tem ganho uma grande força e as suas várias modalidades têm-se difundindo por todo o mundo, tendo em conta que oferece soluções para vários problemas da transportação urbana, assim como a direciona num caminho mais sustentável. Os e-scooter sharing systems são um dos tipos de micromobilidade e têm conquistado grandes áreas urbanas por todo o mundo, incluindo Portugal, como um novo tipo de transporte partilhado de uso individual.

Apesar de todos benefícios que derivam dos e-scooter sharing systems, a eficácia do seu desempenho depende da aceitação e aderência das pessoas. Deste modo, e tendo em conta o quão recente este novo tipo de micromobilidade é, é importante estudar quais os fatores que influenciam a intenção dos indivíduos de os utilizar. Resumindo, o objetivo do presente estudo é estudar a intenção dos e-scooter sharing systems na cidade de Coimbra, Portugal.

Com esse propósito, com base no modelo teórico desenvolvido neste estudo, inspirado nas teorias Theory of Planned Behaviour e Unified Theory of Acceptance and Use of Technology 2, um survey foi criado e partilhado, tendo sido recolhidas 356 respostas válidas de estudantes do ensino superior de Coimbra.

O modelo de investigação sugerido estuda o efeito de sete variáveis na Intention to use ESS, sendo elas, Perceived Behaviour Control, Subjective Norm Peers, Subjective Norm Media, Price Value, Perceived Risk, Environmental Concerns e Sharing Propensity.

Os resultados demonstram que o Perceived Behaviour Control e Subjective Norm Peers são os fatores que têm maior impacto na Intention to Use, seguidos das Environmetal Concerns. As relações entre a Intention to Use e os restantes fatores em estudo não são significativas. A partir deste estudo, identificam-se quais os fatores que contribuem para a intenção dos indivíduos utilizarem os e-scooter sharing systems, o que pode oferecer informação importante para melhorar a adoção dos serviços de e-scooter sharing.

Palavras-chave: Micromobilidade, E-scooter sharing, Transportação urbana, Intenção, Coimbra, Portugal.

Abstract

In the latest years, micromobility has gained a great strength and its various modes are spreading worldwide, as it offers solutions to several problems of urban transportation, as well as directs it in a more sustainable path. E-scooter sharing systems are one of micromobility modes and have conquered huge urban areas all over the world, including Portugal, as a new type of shared transportation for individual use.

Despite all the benefits derived from e-scooter sharing systems, the effectiveness of their performance depends on people's acceptance and adherence. Thus, and given how recent this new type of micromobility is, it is important to study which factors influence the individuals' intention to use them. In short, the aim of the present study is to study the intention of e-scooter sharing systems in the city of Coimbra, Portugal.

For this purpose, based on the theoretical model developed in this study, inspired by the Theory of Planned Behaviour (TPB) and Unified Theory of Acceptance and Use of Technology 2 (UTAUT2), a survey was created and shared, and 356 valid answers from Coimbra college students were collected.

The suggested research model studies the effect of seven variables on Intention to use ESS, these being Perceived Behaviour Control, Subjective Norm Peers, Subjective Norm Media, Price Value, Perceived Risk, Environmental Concerns and Sharing Propensity.

The results show that Perceived Behaviour Control and Subjective Norm Peers are the factors that have the greatest impact on Intention to Use, followed by Environmental Concerns. The relationships between Intention to Use and the remaining factors under study are not significant.

This study identifies the factors that contribute to individuals' intention to use e-scooter sharing systems, which can provide important information to improve the adoption of e-scooter sharing services.

Keywords Micromobility, E-scooter sharing, Urban transportation, Intention, Coimbra, Portugal.

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SYMBOLS AND ACRONYMS

List of Symbols

B - Path coefficient

Acronyms/Abbreviations

IEA - International Energy Agency

AFVs - Alternatively fuelled vehicles

MaaS - Mobility- as-a-Service

TNCs - Transportation Network Companies

ICT - Information and communications technology

ESS - E-scooter sharing services

BSS - Bikesharing services

DBS - Dockless bikesharing

TPB - Theory of Planned Behaviour

PBC - Perceived Behavioural Control

TAM - Technology Acceptance Model

UTAUT - Unified Theory of Acceptance and Use of Technology

TRA - Theory of Reasoned Action

UTAUT2 - Unified Theory of Acceptance and Use of Technology 2

SUI - Sustainable usage intention

MBSS - Bicycle sharing system in Mashhad

SNP - Subjective Norm Peers

SNM - Subjective Norm Media

PV - Price Value

SP - Sharing Propensity

PR - Perceived Risk

CFA - Confirmatory factor analysis

CR - Composite reliability

CA - Cronbach's alpha

EC - Environmental Concerns

FL - Factor loadings

AVE - Average variance extracted

CMIN/df - Chi-square value per degree of freedom

CFI - Comparative fit index

IFI - Incremental fit index

AGFI - Adjusted goodness of fit index

RMSEA - Root mean square error of approximation

SRMR - Standardized root mean square residual

MGA - Multigroup analysis

1. INTRODUCTION

At present urban mobility faces a variety of obstacles generated by population growth and urbanization trends (Öztaş Karlı et al., 2022). In addition, the accelerated growth of motorization in developed countries is a challenging problem for the sustainability of urban mobility, as the increase in the quantity of cars can also cause serious negative effects (Malichová et al., 2020; Safdar et al., 2022). The disadvantageous effects associated with these problems include high carbon emissions, traffic congestion, noise, air pollution, parking problems and long travel times. (Eccarius & Lu, 2020; Öztaş Karlı et al., 2022).

According to the International Energy Agency (IEA), 49.9% of transportation is powered by fossil fuels, which account for 8.4% of the world's CO2 emissions (Ho & Wu, 2021). The intensive use of non-renewable energy resources such as fossil fuels is causing serious problems such as climate change, global warming, carbon dioxide emissions and a general energy crisis throughout the world (Ho & Wu, 2021).

Thus, governments have endeavoured to devise alternatives to proactively mitigate these harmful after-effects, such as the development of electric transportation (Ho & Wu, 2021). Furthermore, researchers, industries and police-makers have been committed to discovering new transport options, such as shared mobility and alternatively fuelled vehicles (AFVs), where electric vehicles are included (Burghard & Dütschke, 2019).

Shared mobility is a new means of transportation, which aims to make greater use of mobility resources (Malichová et al., 2020). Shared mobility is composed by several services such as car sharing, ridesharing and micromobility services, including bikesharing and e-scooter sharing, the latter being the focus of this thesis. From the user's point of view, shared mobility brings more drastic changes in daily mobility behaviours and therefore implies a greater break from the usual habits of the population, while AFVs cause only slight changes in vehicle use (Burghard & Dütschke, 2019).

There is a consensus that urban mobility needs to become more sustainable and shared mobility solutions offer opportunities to solve some of these related problems (greenhouse gas emissions, traffic congestion, etc.) with greater resource efficiency (Malichová et al., 2020).

Regarding micromobility, its services have registered significant growth worldwide and have transformed mobility patterns in many cities (McKenzie, 2020). In 2017, e-scooter sharing emerged as a new micromobility system and quickly gained much popularity around the world.

E-scooter sharing systems make use of electric vehicles, in particular e-scooters (Öztaş Karlı et al., 2022; Song et al., 2022) and offer a solution to the first-mile/last-mile problem, contribute to the mitigation of traffic congestion in cities, are emission-free, contributing to the reduction of greenhouse gas emissions and, finally, are energy-saving (Song et al., 2022). These are some of the many aspects that underpin the large uptake of e-scooter sharing.

E-scooter sharing systems bring many benefits and are the most recent solution to the sustainability problems of urban transportation, so there is still a lot to be studied. Therefore, this thesis focuses on e-scooter sharing systems, given that they are very recent as their first implementation appeared only 5 years ago. In addition, most of the literature has addressed the advantages, disadvantages and sustainability of these services, however, knowledge about the factors that lead to the intention or not to use them has yet to be consolidated. This thesis thus contributes to fill this research gap.

All in all, the rapid development of micromobility systems, in particular e-scooter sharing, is one of the most recent and current study themes in the area of urban mobility and acceptance of new technologies (Blazanin et al., 2022). These systems spread rapidly around the world and at present the various companies, such as Bolt, Bird, Lime, among others, compete on the global market and carry a relative amount of risk capital.

All these global companies have (or have had) operations in several Portuguese cities, leading to believe that Portugal appears to be an important test market.

The survey carried out in this thesis was conducted in the city of Coimbra, not only because this was one of the first Portuguese cities to test e-scooter sharing systems, but also due to its characteristics. Coimbra is one of the largest and most important Portuguese university cities, having a great suitability for a study on this topic, given that e-scooter sharing systems are generally targeted at younger age groups.

In this work, the focus will be on understanding, from the customer's perspective, what factors lead their intention to use e-scooter sharing. Therefore, this study aims to study the intention to use e-scooter sharing services in the city of Coimbra, Portugal and intends to:

- Establish a theoretical model to explain the intention to use these systems;
- Develop a questionnaire directed to Coimbra students to understand their behaviour and opinions regarding these micromobility systems;
- Understand which variables have an effect, either positive or negative, on the intention to use e-scooter sharing;
- Study the effect of gender on the relationships between the variables under study and the intention to use e-scooter sharing systems.

The rest of this thesis begins with a literature review in the first section and methodology and hypothesis is presented in the second section. In the third section, an analysis of the data is presented, followed by a description and discussion of the results.

2. LITERATURE REVIEW

2.1. Shared Mobility

In recent years, among other things, technology has been powering the transition from traditional travel modes to shared mobility (Standing et al., 2021), with shared mobility services being classified as a major urban transport revolution (Aguilera-García et al., 2020; Fulton, 2018).

Data from Shared Mobility, confirms the growth of the shared mobility market, estimated to exceed 60 billion dollars in value in the markets of Europe, China, and the United States of America, with an expected annual growth rate of over 20 percent until 2030 (van Veldhoven et al., 2022).

The term "shared mobility" refers to a diversity of transportation modes that are shared (Shaheen et al., 2016; Burghard & Dütschke, 2019), allowing travellers to use them when they need them and thus constituting a remarkable solution to the adversities of transportation systems (Shaheen et al., 2016; Ko et al., 2021).

In 2016, Shaheen & Chan have defined shared mobility as "an innovative transportation strategy defined as the shared use of a vehicle, bicycle or other mode which enables users to gain short-term access to transportation modes on an as-needed basis." (Aguilera-García et al., 2020).

Shared mobility includes a variety of transport services ranging from sharing the vehicle itself, such as carsharing, bikesharing and e-scooter services options, to services where the ride itself is shared, such as carpooling services (Guyader et al., 2021; Sprei, 2018)

The demand for shared mobility services has been constantly growing due to its inherent advantages (Ko et al., 2021). This type of mobility not only provides new possibilities in terms of cost, autonomy, and flexibility (Efthymiou et al., 2013), but also fills in equity gaps (Safdar et al., 2022). Shared mobility thus contributes to a change in the transport system (Burghard & Dütschke, 2019)

The use of existing shared mobility services provides people with an alternative to owning their own cars, free of future operating expenses and an increase in urban problems

(Ko et al., 2021). Shared mobility does not only include alternatives of using cars, but also offers options using bicycles, motorbikes, among other vehicles (Burghard & Dütschke, 2019).

The first of these innovative transport services to be implemented were bikesharing services and later carsharing systems (Aguilera-García et al., 2020). These types of services have had a growing demand since their implementation, impacting not only the provision of transport in urban areas, but also promoting a more environmentally friendly mobility (Aguilera-García et al., 2020).

The various shared transport services can be used over a wide range of trip distances and vary in flexibility, as shown in Figure 2.1 (Guyader et al., 2021). The main modes will be analysed in more detail below.

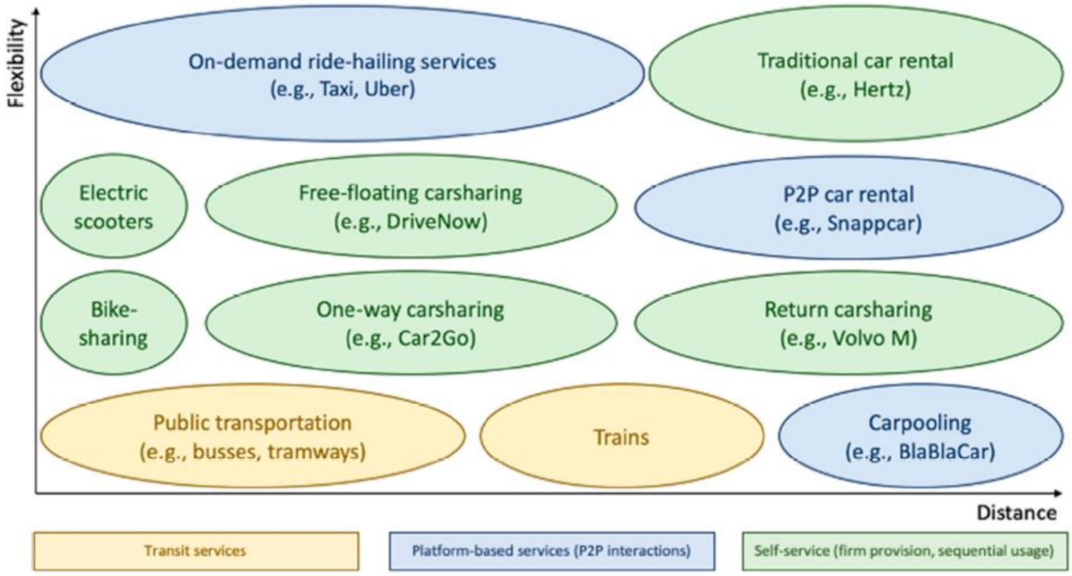

Figure 2.1. Shared mobility modes. Note: this representation excludes leasing (assimilated to permanent ownership), Mobility- as-a-Service (MaaS), or "Mobility-as-Network" systems and other "all-in-one" integrated combinations of various shared mobility modes and delivery services (i.e., P2P packages, crowd-logistics, and on-demand delivery).

2.1.1. Shared mobility modes

2.1.1.1. Carpooling Services

According to Guyader et al. (2021) "Carpooling is adding additional passengers to a pre-existing car trip—such an arrangement allows drivers to fill otherwise empty seats in their vehicles.".

Technology has facilitated the dynamics of this service, allowing passengers to meet each other more efficiently through digital platforms and mobile phone apps, such as Zimride and BlaBlaCar (Guyader et al., 2021). The carpooling services apps match passengers with similar paths and destinations, allowing them to share the ride with strangers or fellow colleagues or co-workers, often at lower prices (Long & Axsen, 2022).

Carpooling services make the best use of empty seats in vehicles (Si et al., 2022), having multiple inherent benefits, such as cost savings and reduced environmental impact, considering that ride sharing decreases the number of cars on the roads (Guyader et al., 2021; Standing et al., 2021).

2.1.1.2. Ride-Hailing Services

Ride-hailing or ride-sourcing services operate identically to taxi services supplied by professional trained and licensed drivers for remuneration, where riders use mobile applications to request a ride and also pay for it (Guyader et al., 2021; Long & Axsen, 2022).

The main difference between ride-hailing services and carpooling services is that in ride-hailing users do not only pay for fuel and distance travelled, but also for the professional drivers' time (Guyader et al., 2021).

The company Uber, founded in 2009 in California, is one of the best-known Transportation Network Companies (TNCs) offering ride-hailing services (Guyader et al., 2021). Along with Lyft, these are the two largest companies offering ride-hailing services, generating millions of rides per year worldwide (Long & Axsen, 2022).

According to a report conducted by Deloitte, Uber users are picked up in four and a half minutes, while a taxi takes eight minutes to reach the customer. This type of service not only has advantages such as a lower risk due to the knowledge of the passenger and driver profiles before the pickup, but also has a lower travel cost (Standing et al., 2021).

2.1.1.3. Carsharing Services

In carsharing services, customers pay a fixed price for a membership plan and a flexible fee according to use (Guyader et al., 2021). Customers who opt for this type of service drive themselves in vehicles that are shared within the company that provides the car rental system (Long & Axsen, 2022).

The development of information and communications technology (ICT) allows carsharing to enable users to share the ownership and use of vehicles. The carsharing services provide various options for their customers to use these systems, such as one-way car-sharing, two-way or round-trip car-sharing, and free-floating car-sharing sharing (Greenblatt & Shaheen, 2015).

The first model of carsharing was introduced in 1948, in Zurich, Switzerland and it was spread worldwide to many cities over the years (D. Zhang et al., 2019).

Recently, a study found that the number of users of carsharing systems, as well as the number of vehicles owned by this type of service are increasing worldwide at a rate of 35% and 30% per year, respectively (de Luca & di Pace, 2015).

Like all transportation modes, carsharing systems have their advantages and disadvantages from the perspective of the user or potential user. Some inconveniences such as having to make a reservation prior to use a car, the need to drive to the service station to pick up the car and running the risk of there being no car available for use may exist (Burghard & Dütschke, 2019). However, the customer enjoys several benefits, such as the autonomy and convenience of having a car, but without the inconveniences of maintenance, insurance, etc. (Guyader et al., 2021).

At the society level, carsharing provides several advantages, considering that it helps to reduce car ownership as well as car purchase (Giesel & Nobis, 2016). In addition, there is evidence that users of this type of service travel fewer kilometres after becoming members (Burghard & Dütschke, 2019).

2.1.1.4. Micromobility

Micromobility is a mode of shared mobility and briefly, its services include a fleet of vehicles, mainly bikes and e-scooters, as a means of personal transport in urban areas (Eccarius & Lu, 2020), where customers pay for their usage rate. Micromobility will be discussed in more detail further down the document since it will have an exclusively dedicated section.

2.1.2. Shared mobility advantages and disadvantages

Shared mobility impacts urban planning in four dimensions: travel behaviour, environmental, land use and social (Aguilera-García et al., 2020).

Therefore, it presents a number of advantages such as: i) The provision of alternative means of transport, which can be more convenient than a private vehicle (Barth & Shaheen, 2002) and more flexible than public transport, provides an agile way to make short, medium and even long-distance trips (Jie et al., 2021). It can be particularly useful in first and last mile connections with public transportation (Biehl et al., 2019); ii) Shared mobility is expected to decrease users' transport costs (Aguilera-García et al., 2020), improving the access to transport for economically disadvantaged groups, who cannot afford private means of transport (Eccarius & Lu, 2020); iii) With vehicle sharing, their downtime is shorter and consequently less parking space is required in cities (van Veldhoven et al., 2022); and iv) Shared mobility contributes to solving problems such as air pollution, given that shared mobility services are heavily based on electric or hybrid vehicles (Aguilera-García et al., 2020). In addition, it has an impact on reducing congestion in urban areas, as well as reducing global warming, due to the reduction of trips made by private vehicles (Jie et al., 2021).

Although there are many points that favour shared mobility services, they have not yet been fully well embedded in most people's transportation habits (van Veldhoven et al., 2022). Furthermore, despite claims that these services are environmentally friendly, studies done in Indonesia point out that they are not effective in reducing carbon dioxide emissions and air pollution in general (Standing et al., 2021). In contradiction to the above, some experts predict that shared mobility services may impact traffic negatively rather than positively (Huang, 2021; Standing et al., 2021).

2.2. Micromobility

Micromobility is one of the shared mobility modes and thus forms part of urban transportation. Micromobility services are a new and rapidly emerging mode of urban transportation and therefore are attracting the attention of many researchers (McKenzie, 2020).

All over the world, micromobility sharing services have been gaining a great popularity in urban areas. Data shared by NACTO (2020), indicate that 136 million rides in 2019 in the United States were made through these services, noting an increase compared to other years, especially due to the rise of e-scoters sharing services in particular (Reck & Axhausen, 2021).

Although micromobility is an increasingly used term in the transport literature, it still does not have yet a globally accepted definition (Eccarius & Lu, 2020). Generally, micromobility is related to the use of small and light vehicles or devices, such as powered two-wheelers for short-distance travel (Eccarius & Lu, 2020).

Micromobility services include a fleet of such vehicles, mainly bikes and e-scooters, as a means of personal transport in urban areas (Eccarius & Lu, 2020), where customers pay for their usage rate (Guyader et al., 2021).

The operating mode of micromobility services generally works as follows: 1) locate an available vehicle through the mapping interface of a mobile application; 2) the user finds the vehicle and unlocks by scanning a QR code generated in the app to start his trip; and 3) at the end of the journey the user can leave the vehicle at any public place in the urban area and lock it through his mobile device (McKenzie, 2020).

Some advantages arise with the expansion and use of micromobility services in large cities, such as a smaller carbon footprint, less occupied road space (Eccarius & Lu, 2020) and reduced noise in large cities (van Veldhoven et al., 2022).

According to McKenzie (2020), during high traffic periods, micromobility services offer on average faster trips than ride-hailing services, for example. A large number of companies have been setting up in urban areas, offering through micromobility services low-cost transport alternatives for short-distance trips (McKenzie, 2020).

In addition, micromobility systems are a mode of transport that can be less stressful as it avoids driving in congested traffic and also less expensive than cars, either for their maintenance or parking fees (Blazanin et al., 2022).

2.2.1. Micromobility Services

Dockless bikesharing services and dockless e-scooter sharing services are the most generic micromobility services (Blazanin et al., 2022). Although these are the best known and currently used, docked bikesharing services have been around for over a decade.

However, dockless systems have an added value, considering that they provide a more uncomplicated and effective service, since the equipment used can be left anywhere convenient for the user (not needing to be delivered to a specific location or station) (Z. Chen et al., 2020).

E-scooter sharing services (ESS) and bikesharing services (BSS) are especially suitable for short or last-mile trips and usually make use of electric vehicles (either bicycles or scooters) (Abduljabbar et al., 2021; Baek et al., 2021).

In essence, the two main existing and currently available micromobility services are based on bikesharing services and e-scooter sharing services and both will be discussed separately in order to characterise and distinguish them.

2.2.1.1. Bikesharing Services

Bikesharing services are available in urban areas with high concentration of destinations, allowing customers to have at their disposal, at any time, regular or electric bicycles from a network of dock-based stations or free-floating based in GPS and mobile apps for short distance travels (Biehl et al., 2019; Eccarius & Lu, 2020). Fleet's maintenance, storage and parking issues are the responsibility of the service provider (Guyader et al., 2021).

The first bikesharing system developed for the public appeared in 1965 in the Netherlands (Lyu & Zhang, 2021). Since then, its evolution has been supported by the development of technologies, using mobile apps and online payment facilities. These elements are central to the large-scale diffusion of bikesharing systems, considering that they provide technical accessibility (Zhou et al., 2021).

Since 2004, the bikesharing systems have spread to most metropolitan cities, initially through government incentives and later through private organisations such as Jump's (Guyader et al., 2021).

With environmental pressures and urban traffic problems arising in many countries, bikesharing systems have emerged to help address these adversities (Ji et al., 2021). At the same time, they have made available to citizens a new way of travelling in large cities, which ultimately complements existing public transport options (Lyu & Zhang, 2021).

Dockless bikesharing (DBS) are an updated version of bikesharing services, characterised by the absence of bicycle pick-up and drop-off stations (Gu et al., 2019). This new model of bikesharing was first implemented in China in 2016 and has since become very popular worldwide (Manca et al., 2019).

In short, with DBS, customers do not need to go to a station to pick up a bicycle for their trips, nor do they have to return to a station of the respective service to deliver it. With this new version of bikesharing services, customers can casually find parked bikes in the city where they are allowed or even search on the service's mobile phone app where bikes are available, using GPS. Furthermore, DBSs offer an easy and convenient service considering that the user can locate, unlock and pay for the use of the bicycle all through a mobile phone application. At the end of their journey, the customer can leave their bicycle at the nearest convenient location where parking is allowed (M. Chen et al., 2020). This service is thus an asset for "the last miles" problems in daily commuting (Li & Lin, 2022).

Bikesharing systems, apart from all the conveniences they offer to their customers, are also recognised as eco-friendly and contribute to sustainability in the urban transport sector (X. Zhang et al., 2021).

These services are one of the resources that tackle the problems of air pollution and congestion, as they are low in emissions and in addition, an increasing uptake of bikesharing services can signify a decrease in the use of motor vehicles with high levels of gas emissions (Ye, 2022). Finally, adding to the environmental benefits inherent to these sharing systems, their implementation can also encourage physical activity (Ye, 2022).

However, bikesharing services also carry some drawbacks, given that they do not allow the transport of large loads and their use is not appropriate or desirable on a day with adverse weather conditions (X. Chen, 2022). Beyond that, some safety issues arise, given that, for example, many bicycle users do not consider the importance of wearing helmets (Martin et al., 2016). BSS also entail some challenges in their management. Greed and exacerbated business expansion has led to serious financial crises of many bikesharing companies (Zhou et al., 2021), as was the case of Ofo, one of the largest providers of this service in China (Y. Zhang & Mi, 2018).

In addition, some aspects have reduced user satisfaction, such as the amount of abandoned bicycles on city streets (Y. Wang & Szeto, 2018) and also the incorrect parking of them, becoming obstacles in public spaces and interfering with the operation of public transportation (Y. Wang & Szeto, 2018).

2.2.1.2. E-scooters Sharing Services

The other component of micromobility systems are e-scooter sharing services. Fundamentally, these services work like free-floating bikesharing or carsharing systems, but using electric kick-bikes instead. These systems are based on a geo-fenced network of e-scooters, allowing users to unlock them on-demand in urban areas (Guyader et al., 2021). From smartphone applications, customers have access to e-scooter sharing services wherever and whenever they need or want (Feng et al., 2022; McQueen et al., 2021).

Shared e-scooters were initially introduced in 2017 in the United States of America (Gössling, 2020) and have managed to achieve a large uptake over the past 5 years (Öztaş Karlı et al., 2022).

E-scooters have diffused in urban areas for their greater flexibility compared to other means of transportation, despite being limited in terms of travel distance. In addition, while some studies support e-scooters as environmentally friendly solutions, others raise safety issues (Guyader et al., 2021).

Electric scooters offer a solution to the last-mile problem, having conquered many city inhabitants around the world since 2017 (Kopplin et al., 2021). Smith and Schwieterman (2018) research, indicate that e-scooter sharing services can be a strong alternative to short distance trips with private automobiles, which is supported by a study by Hardt and Bogenberger (2019)¸ in Munich, Germany, whose results show that electric scooter trips may replace local car trips (McKenzie, 2020).

According to Degele et al. (2018), e-scooters are most used to travel distances between 1 and 6 kms, and thus for short distances they may replace walking (Kopplin et al., 2021). Also, Eccarius and Lu (2018) in an exploratory study, found that 50 to 80 % of potential trips to be made through the use of an e-scooter sharing service by potential users, were previously made by walking, cycling or public transport (Eccarius & Lu, 2020).

E-scooter sharing services are easily integrated with public transport systems and promote several benefits, such as reducing carbon emissions, private vehicle use and also traffic congestion (Öztaş Karlı et al., 2022).

Despite numerous environmental advantages inherent in micromobility, there are contradictory statements claiming that e-scooters may end up emitting more CO2 in the long term due to their short life cycle (Moreau et al., 2020).

2.3. Adoption and intention: Theories and Models

For many years, researchers have been dedicated to the study of behaviours, attitudes and willingness in relation to particular cases, such as the perception of a product or service (Si et al., 2020). There are several theories, models and their variants aiming to explain and measure intention and adoption of new technologies, as we can see in Figure 2.2.

These theories and models seek to find out which variables influence an individual's intention to use a product or service or its use itself (Javadinasr et al., 2022). In this thesis only those that are most commonly used in the studies developed on intention and adoption of shared mobility or similar systems will be addressed.

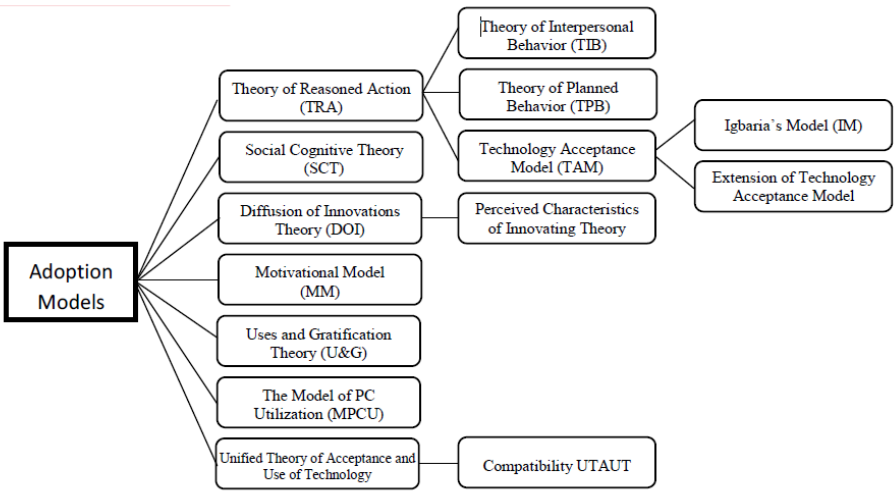

Figure 2.2. Adoption Models (Taherdoost, 2018)

2.3.1. Theory of Planned Behaviour

The Theory of Planned Behaviour (TPB) developed by Ajzen in 1991 is a theory that is commonly used to model human behaviour and has been applied in a wide diversity of research fields, such as education, healthcare, as well as mobility (van Veldhoven et al., 2022).

TPB, illustrated in Figure 2.3, highlights the psychological factors of interesting usage behaviours and has been applied in studies about transit, environmental protection and sustainable behaviours including sustainable transport usage (Si et al., 2020). Thereby, TPB is useful to explain behaviours such as bikesharing intentions or other similar systems (Kaplan et al., 2015).

TPB is composed by several factors that originate the formation of intention: attitude, perceived behaviour control, and subjective norms, being intention the dependent variable in this theory. In the lens of the Theory of Planned Behaviour "Intention is assumed to be an immediate antecedent of behaviour" (Ajzen, 2002) and therefore usage is more probable if intention to use is elevated (van Veldhoven et al., 2022).

The first determinant of intention is attitude, defined by Ajzen (1991) as: "the degree to which a person has a favorable or unfavorable evaluation or appraisal of the behavior in question" (Ajzen, 1991).

The second determinant of intention is Perceived Behavioural Control (PBC) indicated as "the perceived ease or difficulty of performing the behavior and it is assumed to reflect past experience as well as anticipated impediments and obstacles" (Ajzen, 1991). Relating this factor to the intention to adopt micro-mobility sharing systems, perceived behavioural control will correspond to the perceptions that users have about the ease or difficulty of using electric scooter sharing services (Ajzen, 1991). This ease or difficulty of using micromobility services is related to the user's availability of time and money, as well as the degree of confidence the user has in their ability to use this form of transportation (Taylor & Todd, 1995).

Finally, the third and last determinant is subjective norm, defined by Ajzen as "the perceived social pressure to perform or not to perform the behavior" (Ajzen, 1991) ie, the pressure made by family, friends or peers to use or not use shared micromobility services (Amjad & Wood, 2009).

In essence, the more positive the attitude, the more support we receive from the people with whom we most relate and the more consistent and stronger the perceived control of the behaviour, the greater the intention to execute the behaviour in question and vice versa (Ajzen, 2011).

In the effort to improve the interpretive quality of the Theory of Planned Behaviour, many researchers have inserted new variables into the model of this theory (Ding et al., 2018), such as Beck and Ajzen (1991) that concluded that moral obligation could enrich the prediction of intention to perform a behaviour in an ethical manner (Si et al., 2020).

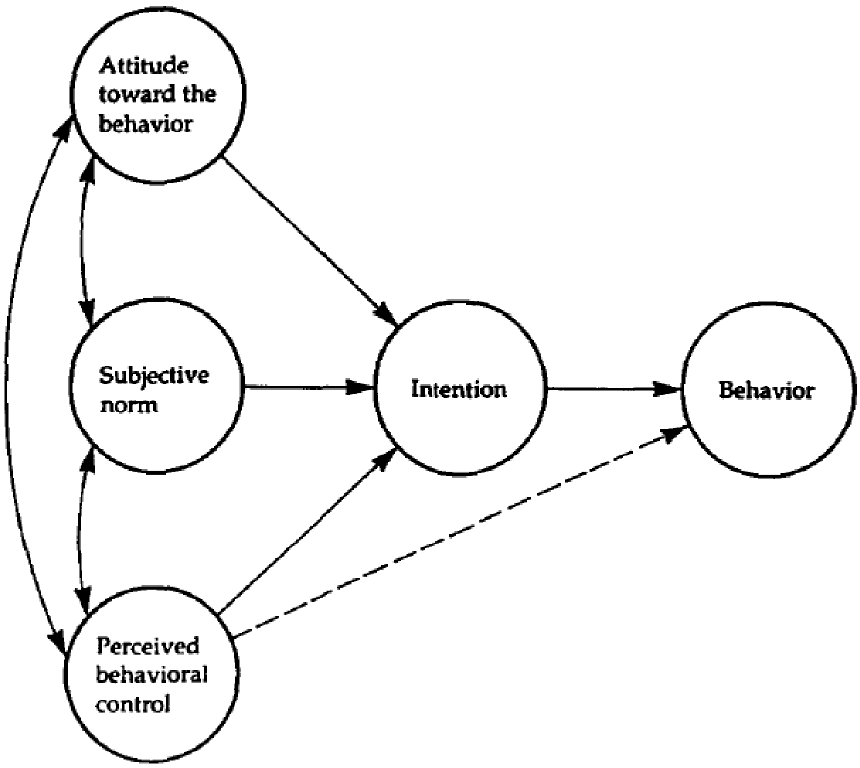

Figure 2.3. TPB (Ajzen, 1991)

2.3.2. TAM

The Technology Acceptance Model (TAM) was conceived by Davis in 1985 and determines the acceptance of a new technology by consumers (Javadinasr et al., 2022). This theory proposes that two factors contribute to the adoption of a certain technology, perceived usefulness and perceived ease of use (Li & Lin, 2022), which are antecedents of attitude and intention to adopt a new technology or behaviour, as can be seen in Figure 2.4 (Adu-Gyamfi et al., 2022; Venkatesh & Davis, 2000).

Perceived usefulness refers to how helpful and problem-solving a new technology is (Venkatesh & Davis, 2000) and how much it can increase a person's work productivity (Davis, 1989). Perceived ease of use refers to how easy the use of a new technology can be, i.e. whether it can be used with little effort (Davis, 1989; Kim et al., 2018). It means that if a person thinks that a technology is useful for him/her and if it does not require a great effort to use it, he/she will be more willing to adopt the new technology (Javadinasr et al., 2022).

TAM was initially applied to study initial acceptance, however, researchers have been adopting it to assess continuance behaviour and post-adoption behaviour (Lin & Filieri, 2015; Weng et al., 2017). This theory has been applied in several technology studies, including transportation technology, and some have been conducted to predict the intention to adopt bikesharing systems in recent years (Li & Lin, 2022).

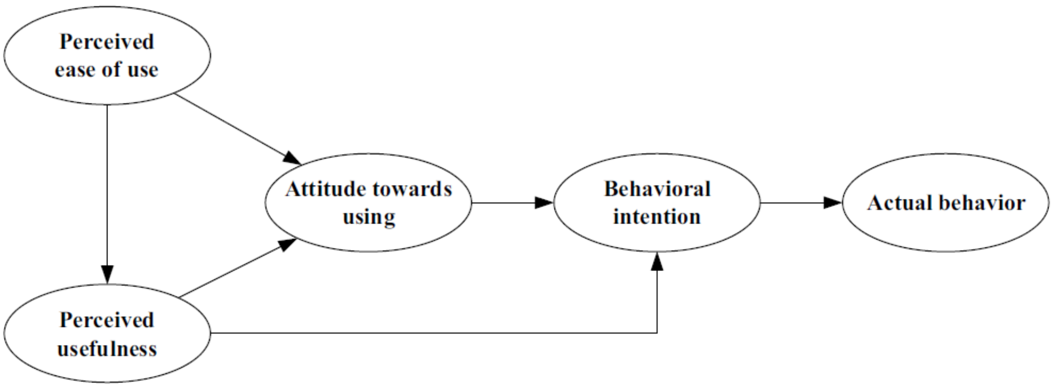

Figure 2.4. TAM Model (Y. Wang et al., 2020)

2.3.3. UTAUT

Technology acceptance is a relevant topic for several research areas, hence there are so many theories and models that aim to study and explain it. The Unified Theory of Acceptance and Use of Technology (UTAUT) is a more advanced model of technology acceptance, which provides more comprehensive results about acceptance behaviour, than other existing models and theories (Venkatesh et al., 2003).

The UTAUT model is an assemblage and adaptation of eight theories and models of technology acceptance, these are: Theory of Reasoned Action (TRA), Technology Acceptance Model (TAM), and Theory of Planned Behaviour (TPB), Theory of diffusion of innovations, Social Cognitive Theory, Motivational Model, Personal computer use model, and Combined Theory of planned behaviour/technology acceptance model (Jahanshahi et al., 2020).

In order to study and understand the behavioural intention and the behaviour itself, this model contains the constructs Performance Expectancy, Effort Expectancy, Social Influence and Facilitating Conditions (Jahanshahi et al., 2020).

The factors Effort Expectancy and Performance Expectancy are similar to the constructs included in the TAM, being directly related to the perceived ease of use and perceived uselfuness, respectively (Jahanshahi et al., 2020).

In addition, the UTAUT model also considers the constructs Social influence and Facilitating conditions, to incorporate variables from the social and organizational fields into the model (Legris et al., 2003; Malhotra & Galletta, 1999).

According to Venkatesh et al. (2003), social influence is "the degree to which an individual perceives that important others believe that he or she should use the new system" and is associated with the "subjective norm" variable of TPB (Venkatesh et al., 2003). Finally, Venkatesh et al., 2003 defined Facilitating conditions as “the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system.”(Venkatesh et al., 2003). In other words, it’s the infrastructures or environmental conditions that influence the individual's perception of the difficulty level inherent to the performance of a certain behaviour (Teo, 2010).

In addition to the constructs already mentioned, the UTAUT model also incorporates moderating variables such as age, gender and experience, as illustrated in Figure 2.5. These variables have an effect on the relationships between the four constructs and the dependent variable, Behavioural intention to use a new technology (Brown et al., 2010; Venkatesh et al., 2003, 2012; Wolf & Seebauer, 2014).

Considering that the UTAUT model was developed for corporate structures, posteriorly, Venkatesh et al. (2012) presented a new model, Unified Theory of Acceptance and Use of Technology 2 (UTAUT2), an adaptation of UTAUT (Venkatesh et al., 2003), for the customer context, which explains consumer acceptance and use of technologies.

Therefore, in this new version, UTAUT2, Venkatesh et al. (2012) incorporated a new construct, Price Value, to represent whether an individual considers the cost of using a new technology reasonable, whether that cost is monetary or otherwise.

The UTAUT2 model thus provides better outcomes for the study of consumers' intention and adoption of technology (Öztaş Karlı et al., 2022).

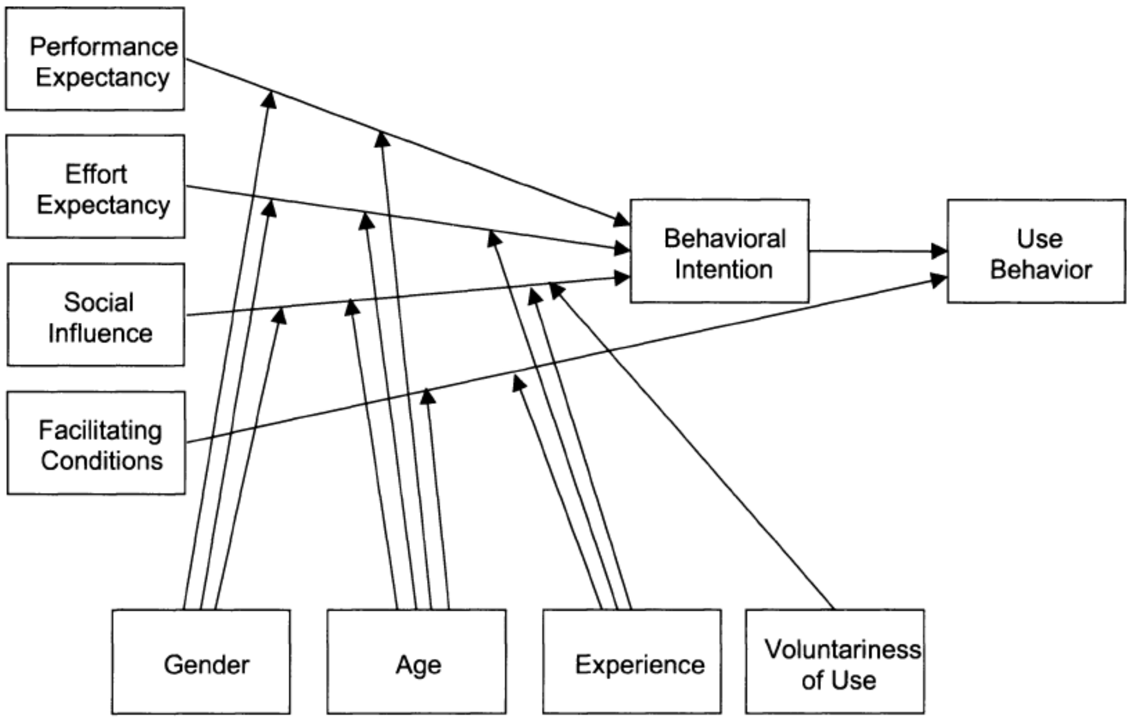

Figure 2.5. UTAUT Model (Venkatesh et al., 2003).

2.3.4. Previous studies

As shown in the previous section, researchers have invested a lot of time in developing models and theories to describe, predict and explain behaviours (Venkatesh et al., 2003). Thus, this section will discuss and describe some studies already conducted in the transportation area, which aim to understand the intention and adoption of technologies developed in this sector.

Eccarius and Lu (2020), conducted a study in Taiwan with the aim of investigating the behavioural determinants of traveller intention to use a micro-mobility service, electric scooter sharing. Using data collected from a survey of 471 university students in Taiwan, a theoretical framework was developed based on the TPB. The framework proposed by this study presents the following additional constructs: Environmental values, perceived compatibility, and awareness-knowledge as the antecedents of the global motives (attitude toward usage, perceived behavioural control and subjective norm) and of the usage intentions (Eccarius & Lu, 2020). It was concluded that the environmental values and awareness-knowledge variables contribute indirectly, through the global motives, to the intention to use, as well as perceived compatibility, although this is the factor that has a greater impact on the intention to use.

Another study, aiming to investigate the public intention to use shared mobility services in Belgium, carried out a survey based on the TPB but with 8 eight additional latent factors: Environmental values, convenience – ease of use, convenience – saving time, convenience – ownership, price value, perceived compatibility, digital savviness and hedonic motivation (van Veldhoven et al., 2022). Van Veldhoven et al. (2022) proposes a behavioural model, with the purpose of understanding the importance of different factors mentioned in the literature. To test the proposed model a survey was conducted in Belgium and collected 481 responses from Belgian participants. Thus, based on the TPB, this model tests several hypotheses of the effects of the eight additional factors, both among themselves and between the global motives and intention to use. The results indicate that subjective norms, perceived behavioural control and perceived compatibility are the variables that most influence the intention to adopt shared mobility services.

Chen (2022) studied the behavioural intention of university students towards bikesharing systems in Zhejiang province, China. The model used was developed based on TPB, additionally analysing the effect of the variables perceived benefits and government policy on the use of bikesharing systems by the students. Data was gathered through a survey of 934 participants, from which was obtained 782 valid responses. According to the findings behavioural intention is positively influenced by attitude, perceived behavioural control and subjective norms and has a positive and relevant effect on bikesharing behaviour, that is, on the use of bikesharing systems. Beyond that, the results also showed that perceived benefits enhance university students' preference for bikesharing and that government policy considerably influences the use of these services.

Also in China, Si et al. (2020) employed an extended version of TPB by adding consequence awareness and moral obligation to investigate dockless bikesharing users' sustainable usage intention (SUI) and behaviour. A questionnaire was conducted, and the valid sample data consisted of 1038 responses. The results show that perceived behavioural control and moral obligation are the most important factors and that awareness of consequences do not have a relevant effect on SUI, contrary to hypothesized relationship. Finally, the empirical results verified that the extended model has a higher interpretative power than the original TPB model with respect to the analysis of sustainable use behaviour of dockless bikesharing users.

Applying an extended TAM model including the variables of perceived quality, perceived convenience and perceived value, Hazen et al. (2015) explores the intention to use bikesharing systems in Beijing, China. To test the proposed model, a survey was conducted. The results revealed that all constructs have a positive effect on intention to use BSS, and that perceived value could be an important factor for potential users' adoption of BSS.

Rejali et al. (2021) investigated the factors influencing the intention to use shared dockless e-scooters in Iran, using an extended version of the TAM by incorporating the constructs subjective norms, environmental awareness, and hedonic motivation. A total of 1078 participants responded to an online survey to collect the necessary data. Findings revealed that subjective norm is the variable with the greatest effect on the intention to adopt these systems, however, environmental awareness is also a good predictor. This study also asked open-ended questions, from which two conclusions were drawn: respondents believe that replacing the use of cars and motorcycles for short distance trips with e-scooters can have good repercussions on the environment; the biggest barrier to the use of e-scooter sharing services is the lack usage regulations and consequent safety problems.

Several studies also perform an integration of two models, such as TAM and TPB to explore the determinants of intention and adoption of shared mobility systems, as is the case of Ji et al. (2021) who studied the impact of five constructs: behavioural attitude, subjective norm, perceived behavioural control, perceived ease of use and perceived usefulness on intention to use dockless bikesharing (DBS). Data was gathered through a survey of 700 participants, from which was obtained 628 valid responses. According to the results, although all constructs have a positive impact on intention, behavioural attitude, subjective norm and perceived behavioural control directly affect behavioural intention, whereas perceived ease of use and perceived usefulness influence it indirectly. The behavioural attitude factor has the greatest effect on intention, followed by perceived ease of use.

To explain the acceptance of shared e-scooters for urban and short distance mobility, Kopplin et al. (2021) presents a conceptual model based on the Unified Theory of Acceptance and Use of Technology, UTAUT2. A survey of 749 responses based on a random sampling among German public transportation services users was conducted and analysed. Findings suggest that environmental concerns and performance expectancy are the factors with the greatest effect on intention to use e-scooter sharing. Furthermore, it was concluded that e-scooters are not yet seen as a relevant means of transport, being more used as a leisure object. Service providers and policymakers should reinforce and emphasise safety measures for the use of e-scooters, taking into account that perceived safety has a negative effect on the intention to use this service.

Adapting the UTAUT2 model, Jahanshahi et al. (2020) aimed to understand what variables influence people's acceptance of bike sharing systems in Mashhad, Iran. The suggested research model explores the relationships between Performance Expectancy, Effort Expectancy, Social Influence, Facilitating conditions, Price Value and Perceived Safety and behavioural intention to use the bicycle sharing system in Mashhad (MBSS), as well as the relationship between behavioural intention and MBSS use. Furthermore, it is also studied whether behavioural intention mediates the relationship between the six factors mentioned and use behaviour and finally, whether age, income, experience, and educational levels of customers have a moderating effect on the relationship between the six constructs and intention. A questionnaire was distributed to the MBSS stations and a total of 271 responses were obtained to test the proposed model. A regression analysis was conducted which showed that all constructs have a positive influence on behavioural intention, except for price value and that the variable that most strongly predicts the intention to use the MBSS is Facilitating Conditions. The moderating effect of age, income, experience and education levels between the constructs and intention was not corroborated.

Finally, Öztaş Karlı et al. (2022) investigated the factors influencing behavioural intention towards e-scooter sharing by employing an extended version of UTAUT2, including the constructs environmental awareness and price sensitivity. The sample data was gathered through a survey of 467 participants in Turkey, from which 413 valid responses were retrieved. The findings revealed that the variables with the highest impact on the intention to use shared e-scooters were social influence, effort expectancy, performance expectancy and price sensitivity. Considering that the most important factor to predict the intention to use e-scooter sharing is social influence, it was concluded that this should be included in marketing strategies, and that it can contribute to an increase in intention through the sharing of experiences with this service by influencers on social media.

2.3.5. Conclusion

The works carried out by researchers on the intention and/or adoption of micromobility systems are in general very recent, considering that both bikesharing systems (in the dockless version) and e-scooter sharing have been created in recent years, together with the technological advancement and the large adherence to smartphones by the world population.

It should be noted that there are currently a greater number of studies on this topic that address bikesharing systems and fewer that focus on the e-scooter sharing phenomenon, which is understandable considering that the latter were introduced more recently, in 2017.

Furthermore, it should be reinforced that most studies in this area only assess the intention to use these systems.

Finally, it is observed that most of the studies published on the intention and/or adoption of these systems have Asian cities as their research location, with a lower number of the same type of studies carried out in Europe.

3. METHODOLOGY

This research aims not only to evaluate the intention to use e-scooter sharing systems in Coimbra, but also to study which factors influence the intention to use them. The research plan of this thesis was formulated based on the work of (Saunders et al., 2012). The present study adopts a positivist philosophy and follows a deductive research approach. As for the nature of the research, this work is classified as an exploratory study and a quantitative mono-method was adopted. The research strategy followed for data collection is the survey and the data is cross-sectional. Given that there is no data regarding higher education students' opinions and behaviours towards electric scooter sharing systems in the city of Coimbra, the questionnaire was chosen as the most appropriate way to collect the information. The questionnaire was shared via online, as it is the fastest and most effective way of obtaining information nowadays.

3.1. Model and hypothesis

As discussed earlier in the literature review, there are several theories and models that study the intention, adoption and acceptance of new technologies. Often researchers form models that consist of a mix of two theories, as is the case of Ji et al. (2021), who combines TPB with TAM. In addition, sometimes researchers also add new variables to these models, to study the effect of a new variable that may bring new conclusions and relevant information for future work carried out in the theme of the developed study.

Following this line of thought, the model proposed in this work consists of a hybrid model that makes a fusion of two theories, the Theory of Planned Behaviour developed by Ajzen (1991) and the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) developed by Venkatesh et al. (2012). Based on these models, it is intended to better capture the factors that influence the intention to use e-scooter sharing systems, as well as to assess this variable.

The variable Intention to use is present in both theories on which the new proposed model is based. According to Azjen (2002), intention to use is the direct antecedent of behaviour and, therefore, the greater an individual's intention to adopt a certain behaviour, the more likely he/she is to actually do it. Recognising the importance of assessing this variable and it being the focus of this thesis, the effect of several factors on the intention to use will be studied.

Perceived Behaviour Control is one of the antecedents of intention in the Theory of Planned Behaviour and is defined as "the perceived ease or difficulty of performing the behaviour and it is assumed to reflect past experience as well as anticipated impediments and obstacles" (Ajzen, 1991, p.188). In the present case, PBC represents the perceptions of potential users of e-scooter sharing systems regarding their ease or difficulty in using these services, as well as their level of confidence regarding their ability to use e-scooter sharing services (Taylor & Todd, 1995b). This factor also covers the perceptions of potential users regarding their access to money, time and other possible resources needed to use these systems. Therefore, a new hypothesis is formulated.

Hypothesis 1: Perceived behavioural control positively influences intention to use e-scooter sharing.

The TPB presents another antecedent variable of intention, Subjective norms defined by Ajzen as "the perceived social pressure to perform or not to perform the behaviour" (Ajzen, 1991). In other words, it corresponds to the pressure felt by an individual from family, friends, and peers to use or not to use e-scooter sharing services. Inspired by a study developed by de Fano et al. (2022) and with the aim of exploring new variables that are current and appropriate to contemporary trends, the variable subjective norms was divided into two, subjective norm peers (SNP) and subjective norm media (SNM).

Thus, the Subjective norm peers factor encompasses the opinions of the people who are most important to the individual, be they friends, peers or even family in relation to a certain behaviour, considering that an individual's willingness to behave in certain ways is often influenced by how their peers view that behaviour (Young & Jordan, 2013).

However, nowadays, with the phenomenon of social media, there is a greater ease of communication, allowing massive dissemination of information. Moreover, according to Bedard & Tolmie (2018), it was confirmed that social media have the ability to influence consumer behaviour and that these have the power to enhance behaviours adopted and shared by their peers on it (X. Wang et al., 2012). Thus, a new variable was defined, Subjective norm media. In conclusion, the subjective norms variable was divided, depending on the influence input, peers, or media. Thus, the following hypotheses were proposed:

Hypothesis 2: Subjective norm peers positively influences intention to use e-scooter sharing.

Hypothesis 3: Subjective norm media positively influences intention to use e-scooter sharing.

In order to incorporate the financial aspect in the proposed model, the Price Value (PV) factor originally used in UTAUT2 was integrated. UTAUT2 defines Price Value as “consumers' cognitive trade-off between the perceived benefits of the applications and the monetary cost for using them” (Venkatesh et al., 2012). In other words, it represents whether an individual considers the cost of using a new technology to be reasonable, whether that cost is monetary or not. The effect of Price Value on the decision to use or not shared mobility systems is not consensual, and the way individuals consider e-scooter sharing may influence their price sensitivity (van Veldhoven et al., 2022). This means that a higher price sensitivity is expected from people who conceive e-scooter sharing services as a substitute for the use of cars, than people who perceive these systems as a complement to car ownership (van Veldhoven et al., 2022). If potential users of e-scooter sharing consider the benefits of this service to be greater than its monetary value, this variable will have a positive effect on their intention to adopt these systems. Thus, the following assumptions were made:

Hypothesis 4: Price Value positively influences intention to use e-scooter sharing.

At present, with greater access to information and considering the increasing awareness of environmental and climate problems facing the world, the population has gained greater sensitivity to sustainability and environmental issues in general. To represent this growing concern and since that e-scooter sharing systems make use of electric vehicles, which are emission-free and therefore contribute to the reduction of greenhouse gas emissions, it was deemed pertinent to include in the proposed model a variable reflecting the environmental responsibility of the potential users of electric scooter sharing systems (Kopplin et al., 2021). E-scooter sharing services make use of electric scooters, evaluated as an environmentally friendly transport, therefore, and based on the work of Kopplin et al. (2021), the following hypothesis is formalized.

Hypothesis 5: Environmental concerns positively influence intention to use.

To the proposed model it was added a variable that constitutes a possible barrier to the adoption of innovative technologies, the Perceived Risk (PR). According to Featherman & Pavlou (2003), Perceived Risk describes the potential for loss when using a product or service due to financial, performance, social, psychological, physical or time risks. The risk perceived by the consumer when using a product or service can lead to dissatisfaction (Adu-Gyamfi et al., 2022), which may constitute an off-putting factor for the use of e-scooter sharing systems. The perceived risk may negatively affect the perceptions of the users of these services, thus, it can be inferred that when the user has a high perception of risk, the lower the possibility of intending to use it. With this consideration in view and based on Chang & Wang (2018) work, which finds that perceived risks are relevant in influencing consumer behaviour of bikesharing systems, the following hypothesis is formulated.

Hypothesis 6: Perceived risk negatively influences intention to use e-scooter sharing.

Currently the sharing economy is inserted in all aspects of social and economic life, this being a new economic mode that brings the consumer access to inactive social resources through information network technology (Ma and Zhang 2019). New technologies such as smartphones, cloud computing and big data have been one of the key players for the expansion and success of the sharing economy. (Zhou et al., 2021)

In recent years, services like house sharing, carsharing and bikesharing have become increasingly common and consequently have achieved greater adherence worldwide (Zhou et al., 2021). The success of these sharing economy applications can be explained by people's growing disinterest in owning things, since it is often more profitable to rent/borrow than to own them (Malichová et al., 2020). Furthermore, the population has been moving towards options that prioritise efficient uses, which are more sustainable and more economical (Malichová et al., 2020). Thus, and taking into consideration that the focus of this study lies on e-scooter sharing systems, which presupposes the sharing of electric scooters among several users, it was deemed pertinent to add a new variable, Sharing Propensity (SP). According to Aguilera's work, the Sharing Propensity construct aims to capture factors such as the willingness to buy second-hand products, the predisposition to use shared products or services and the tendency to avert sharing spaces with strangers. Hence, it is hypothesized that:

Hypothesis 7. Sharing propensity positively influences intention to use e-scooter sharing.

The proposed model is illustrated in Figure 3.1.

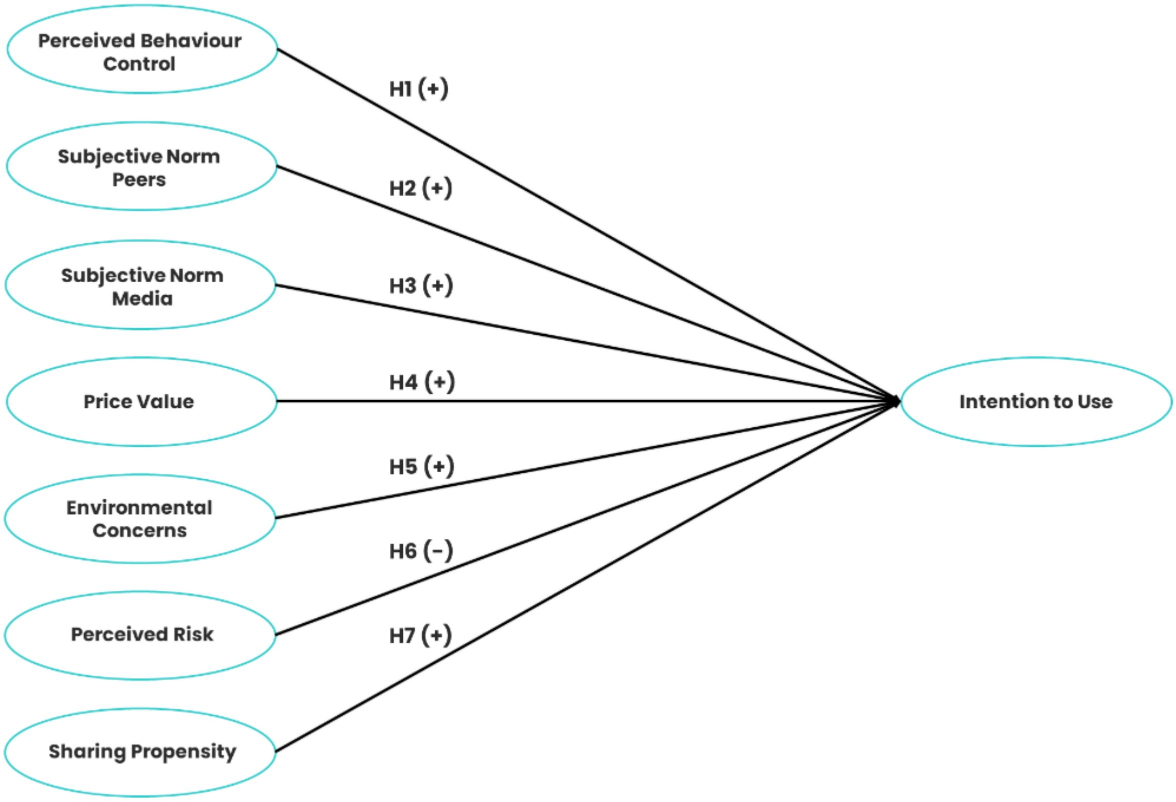

Figure 3.1. Proposed theoretical model.

3.2. Survey design

In order to obtain and collect data concerning the opinions and behaviours of Higher Education students in the city of Coimbra regarding the electric scooter sharing systems in the city in question and therefore investigate the proposed model, a questionnaire was developed. This survey, presented in Table 3.1 was designed and subsequently created in the LimeSurvey platform, from which the participants' answers were collected.

The survey design was structured based on the proposed theoretical model, illustrated in Figure 3.1. The resulting survey comprised a completion time of approximately ten minutes and was divided into three conceptual parts. The first part consisted of a brief introduction, where the context and purpose of the questionnaire were explained. The second part was divided into eight sections, each corresponding to each variable proposed in the theoretical model designed and presented in the following order: Perceived Behaviour Control, Subjective Norm Peers, Subjective Norm Media, Price Value, Intention to Use, Perceived Risk, Environmental Concerns, and Sharing Propensity. Finally, the last part asked about the participant's personal information, such as gender, age, whether he/she is a higher education student, whether he/she had a driving license, and whether he/she had easy/frequent access to a motor vehicle. Questions about usual frequency of use of e-scooter sharing systems, as well as kilometres travelled per usual use and time per usual use, were also asked.

In the second part of the questionnaire, several questions were asked regarding each construct under study. All questions in the survey derived from similar studies and were adapted to the context of the present work.

For the Perceived Behaviour Control variable, all questions were based on Chen (2022) work, which asked whether the respondent thought it was good to use the e-scooter sharing systems, whether he/she was confident and whether he/she thought that he/she had the ability to use them.

Regarding the Subjective norm Peers, based on the questionnaire developed by de Fano et al. (2022), the participant was asked whether most of the people important to him/her think he/she should use the e-scooter sharing systems, whether his/her friends/peers expect him/her to use them, and finally, whether most of the people important to him/her approve of him/her using them. Also based on de Fano et al. (2022) work, to assess the variable Subjective Norm Media participants were asked whether social media posts gave them a positive outlook towards e-scooter sharing systems and also whether articles published on social media influenced them to use these services.

In order to gauge opinions on the Price Value factor, respondents were asked if they think e-scooter sharing systems are affordable, if they consider them a good value for money and if, at the current price, they think these services are a good option. All these questions were taken and adapted from Jahanshahi et al. (2020) work.

As for the Perceived Risk construct, the set of questions resulted from the adaptation of items from Gao et al. (2019) work. The participants answered whether they considered the use of the e-scooter sharing systems risky, whether they thought it added uncertainty to their journey and, finally, whether they considered that the use of these services exposed them to increased risks.

To measure Environmental Concerns, three questions were asked, adapted from the Kopplin et al. (2021) study, in order to assess whether respondents think that e-scooter sharing systems have a positive impact on urban traffic, whether they believe that these systems help to protect the environment and whether they consider that the use of these systems fits with their environmental concerns.

Regarding Sharing Propensity, participants were asked about their willingness to buy second-hand products and to use objects that have been previously used by other people, based on Aguilera-García et al. (2022) work.

Finally, in order to study the focus variable of the present study, Intention to Use, the following questions were asked. With regard to Intention to use, adapted from the work of Eccarius & Lu (2020), respondents were asked whether they would use e-scooter sharing systems if they had close access to them, whether they would be willing to try these services and finally, whether they would be willing to recommend their use to their friends and family.

The questionnaire is the result of the combination of several previously conducted and tested scales. Although the items included in the questionnaire were adapted from studies which used different measurement scales, in the present study, a five-point Likert Scale was implemented to assess the respondent's agreement with the questions. The response possibilities of this Likert scale range from "totally disagree", corresponding to level 1, to "totally agree", referring to level 5.

All questions introduced in the survey were adapted from previous works and were adjusted to the topic in question, e-scooter sharing systems. Furthermore, all questions were duly translated into Portuguese to ensure the easy understanding of the respondents (APPENDIX A). Before the official start of obtaining answers to the questionnaire, a pilot was carried out where responses were obtained from higher education students, who contributed to the correction of minor errors, as well as the response of two university professors to ensure the consistency of the questionnaire.

Table 3.1. Survey

Constructs	Items	Code	References
Perceived Behaviour Control		PBC	
	I think it is good to use E-scooter sharing systems.	PBC1	Han et al. (2017) and Si et al. (2020

	I think I am confident to use E-scooter sharing systems.	PBC2	Han et al. (2017) and Si et al. (2020
	I think that I have the ability to use E-scooter sharing systems.	PBC3	Han et al. (2017) and Si et al. (2020
Subjective Norm Peers		SNP	
	Most people who are important to me think I should use E-scooter sharing systems.	SNP1	Ajzen (1991), Tonglet et al. (2004), Kumar (2019)
	My friends/peers expect me to use E-scooter sharing systems.	SNP2	Ajzen (1991), Tonglet et al. (2004), Kumar (2019)
	Most people who are important to me approve of me using E-scooter sharing systems.	SNP3	Ajzen (1991), Tonglet et al. (2004), Kumar (2019)
Subjective Norm Media		SNM	
	The Social Media post gave me a good feeling about E-scooter sharing systems.	SNM1	Moons and De Pelsmacker (2015)
	Articles in social media influenced me to use E-scooter sharing systems.	SNM2	Moons and De Pelsmacker (2015)
Price Value		PV	
	I think E-scooter sharing systems are reasonably priced.	PV1	(Jahanshahi et al., 2020)
	I think E-scooter sharing systems are good value for money.	PV2	(Jahanshahi et al., 2020)
	At the current price, I think E-scooter sharing systems are a good option.	PV3	(Jahanshahi et al., 2020)
Intention to Use		IU	
	If I have access to E-scooter sharing systems close to me, I will use them.	IU1	(Eccarius and Lu, 2020)
	I am willing to try out E-scooter sharing systems.	IU2	(Eccarius and Lu, 2020)
	I am willing to recommend friends and family to use E-scooter sharing systems.	IU3	(Eccarius and Lu, 2020)
Perceived Risk		PR	
	I think it would be risky to use E-scooter sharing systems.	PR1	(Gao et al., 2019)
	I think using E-scooter sharing systems adds great uncertainty to my journey.	PR2	(Gao et al., 2019)
	I think using E-scooter sharing systems exposes me to increased risks.	PR3	(Gao et al., 2019)
Environmental Concerns		EC	
	I think E-scooter sharing systems have a positive impact on urban traffic.	EC1	(Kopplin et al., 2021).
	I believe that E-scooter sharing systems help to protect the environment.	EC2	(Kopplin et al., 2021).
	I think using an E-scooter sharing system fits my environmental concerns.	EC3	(Kopplin et al., 2021).
Sharing Propensity		SP	
	I am willing to purchase second-hand products	SP1	(Aguilera-García et al., 2022)
	I am willing to use/put on objects that have been used by many people before me	SP2	(Aguilera-García et al., 2022)

3.3. Data collection and sample

The questionnaire was distributed online, and respondents were contacted through social media, such as Instagram and Facebook. The participants had access to the questionnaire by receiving a direct message on the social network with a link to the questionnaire. This study was oriented to obtain a diverse sample of higher education students in the city of Coimbra, so an effort was made to acquire responses from students from different courses, since the faculties and educational institutions in the city are spatially dispersed.

It was chosen to create and distribute the questionnaire online, due to the greater ease and speed in gathering responses, as well as the fact that it does not generate costs, allows greater capacity to obtain a large number of responses and greater ease in guaranteeing the security of the information. However, there are some drawbacks regarding the reliability, validity, response rate and complete completion of the questionnaire (Karlsson, 2016).

In total, 509 questionnaire responses were collected, obtained between 30 May and 10 June 2022. Of the 509 responses obtained, 135 were considered obsolete, as the questionnaire was not fully completed. Of the 374 resulting answers, 18 answers were also eliminated for various reasons, such as incoherence in the answers. In the end, 356 answers were considered valid, which corresponds to an effective response rate of 69.9%.

4. RESULTS

4.1. Descriptive analysis

To better understand the obtained data, it was firstly observed the demographics of the sample, illustrated in Table 4.1. Of the resulting valid sample, 96.1% of the participants were aged between 18 and 24, with a median age of 22 and a standard deviation of 2.3. Considering that the valid sample resulted from a data cleaning process, where responses from respondents who were not higher education students were removed, 100% of the responses considered in this sample are from people who define themselves as university students. As for gender, 34% of the sample identifies with the female gender, while 66% identifies with the male gender.

The questionnaire asked if the respondent had a driving licence, obtaining 83.1% positive answers and 16.9% negative answers. Furthermore, 81.2% of the sample stated that they had easy and/or frequent access to a motorized vehicle.

Regarding the use of e-scooter sharing systems services, 37.6% of the participants declare that they have never used these services, while 62.4% have used them at least once. Table 4.1 shows the frequency of use (trips per month) of university students who stated that they had already used e-scooter sharing systems. As it can be observed, 61.3% of them make between 1 and 5 trips with the e-scooter sharing systems and only 2.3% claim to make between 15 and 20 trips per month, indicating that most students use this form of transportation for exceptions or for leisure purposes and not for daily commuting.

With regard to the distance travelled in each trip using the e-scooter sharing services, 91.9% of people make trips of up to a distance of 4 kilometres, which was already expected, taking into account that these systems are suitable for relatively short trips. In agreement with the answers obtained about the travel distance in each use, 87.4% of the students spend up to 12 minutes in each trip and 79.3% make trips of 3 to 12 minutes.

Table 4.1. Demographic characteristics.

Characteristics	Number	%	Characteristics	Number	%
Age			***Do you have easy/frequent access to a motorized vehicle?***		
18	15	4,2	Yes	289	81,2
19	34	9,6	No	67	18,8
20	40	11,2	***Frequency of ESS use (trips/month)***		
21	67	18,8	1 - 5	136	61,3
22	87	24,4	5 - 10	41	18,5
23	66	18,5	10 - 15	29	13,1
24	33	9,3	15 - 20	11	5,0
25	7	2,0	> 20	5	2,3
26	3	,8	***Km per usual trip***		
27	2	,6	< 1 km	23	10,4
32	1	,3	1 km - 2 km	93	41,9
40	1	,3	2 km - 4 km	88	39,6
Gender			4 km- 6 km	11	5,0
Female	121	34%	> 6 km	7	3,2
Male	235	66%	***Minutes per usual trip***		
Do you have a driving licence?			< 3 min	18	8,1
Yes	296	83,1	3 min - 6 min	77	34,7
No	60	16,9	6 min - 12 min	99	44,6
			12 min - 18 min	22	9,9
			> 18 min	6	2,7

4.2. Measurement model

To test the measurement model, the reliability and validity of the data collected from the questionnaire were assessed by performing Confirmatory factor analysis (CFA) in AMOS 23. It is absolutely necessary to determine reliability, as well as convergent and discriminant validity, because if the factors do not demonstrate appropriate reliability and validity results, it is fruitless to subsequently proceed with the causal model analysis.

Reliability is associated to the consistency of the various metrics used to measure each variable (Fornell & Larcker, 1981). Reliability is usually assessed using Composite reliability (CR) and Cronbach's alpha (CA).

CR depicts how well a set of items can denote a potential construct. According to Fornell & Larcker, (1981), CR guarantees internal consistency if its values are greater than 0,7 and as can be seen in Table 4.2, this requirement is met.

The CA assesses the internal consistency for each construct, indicating the reliability of the model's constructs, which allows defining the accuracy of the measures and moderation of random errors. As suggested by Hair et al. (2010), the CA should present a value greater than 0.7. Table 4.2 shows that all CA values are higher than 0.7, except for two constructs, Subjective norm media (SNM) and Environmental Concerns (EC), which present values of 0.659 and 0.698, respectively. In addition to these results being very close to the required value, according to Pallant (2020), if a construct has less than ten items, it can be considered that CA should be higher than 0.5. Also, some researchers argue that if the CR is greater than 0.7, it is not necessary to refer the value of Cronbach's alpha, as is the case of Bagozzi & Youjae Yi, 1988). In this way, the reliability of the construct is established.

To be considered valid, the proposed model needs to guarantee convergent and discriminant validity (Carmines and Zeller, 1979). Convergent validity tests whether the items of each specific construct converge or share a large proportion of variance. The determination of convergent validity is achieved if the factor loadings (FL) of each item of each construct and the average variance extracted (AVE) of each construct are greater than 0.5 (Hair et al., 2010). As shown in Table 4.2 and Table 4.3, these conditions are met, except for the factor loading of the item EC1, which has a value of 0.493. As this is very close to the value 0.5, it is considered that all the requirements are met and, therefore, it can be declared that convergent validity is obtained.

Discriminant validity determines whether or not a construct is distinct from the others, i.e. each construct must be unique and capture something that the other constructs do not measure. The AVE assesses the amount of variance that is generated for each construct by its items (Bagozzi & Youjae Yi, 1988; S.-Y. Chen & Lu, 2016) and it is based on it that the discriminant validity is obtained. Thus, discriminant validity is achieved when the square root of the AVE of each construct is greater than the correlation of that construct with the other variables (Fornell & Larcker, 1981). Table 4.3 shows the results confirming the discriminant validity, where the square roots of the AVE of each construct are presented on the diagonal (in bold) and the other values, which are below, correspond to the correlation coefficients between the latent variables. If the value of the square root of each variable is higher than the value of the correlation coefficients of this variable with the others, the discriminant validity is proven.

Both the convergent and discriminant validities, as well as the reliability of the proposed model were proven, so it can be considered that the proposed model is apt to be analysed at the structural level.

Table 4.2. Factor loadings, Composite Reliability and Cronbach's alfa.

Indicators	FL	CR	CA
PBC		0,791	0,775
PBC1	0,614		
PBC2	0,879		
PBC3	0,735		
SNP		0,773	0,759
SNP1	0,832		
SNP2	0,738		
SNP3	0,608		
SNM		0,703	0,659
SNM1	0,736		
SNM2	0,736		
PV		0,886	0,884
PV1	0,901		
PV2	0,831		
PV3	0,813		
IU		0,790	0,786
IU1	0,763		
IU2	0,729		
IU3	0,746		
PR		0,777	0,771
PR1	0,779		
PR2	0,810		
PR3	0,600		
EC		0,748	0,698
EC1	0,493		
EC2	0,760		
EC3	0,840		
SP		0,874	0,869
SP1	0,835		
SP2	0,925		

Table 4.3. Fornell-Larcker discriminant validity testing.

Construct	AVE	EC	PBC	SNP	SNM	PV	IU	PR	SP
EC	0,509	**0,713**							
PBC	0,563	0,353	**0,751**						
SNP	0,536	0,356	0,453	**0,732**					
SNM	0,542	0,442	0,233	0,511	**0,736**				
PV	0,721	0,279	0,123	0,249	0,244	**0,849**			
IU	0,557	0,477	0,737	0,544	0,306	0,246	**0,746**		
PR	0,541	-0,238	-0,525	-0,234	-0,064	-0,119	-0,379	**0,736**	
SP	0,776	0,146	-0,029	-0,019	0,014	0,031	0,064	-0,070	**0,881**

4.3. Structural model

To assess whether the proposed theoretical model fits the data collected through the questionnaire, it is necessary to analyse whether the statistics indicating a good model fit are verified. To confirm the model fit, it is necessary to verify that parameters like chi-square value per degree of freedom (CMIN/df), comparative fit index (CFI), incremental fit index (IFI), adjusted goodness of fit index (AGFI), root mean square error of approximation (RMSEA) and standardized root mean square residual (SRMR), are within acceptable thresholds. As can be observed Table 4.4, all the indices under study are within the stipulated limits. Therefore, it is concluded that the proposed model presents a good model fit.

After model fit was proven, the data was analysed using structural equation modelling to test the formulated hypotheses of the theoretical model developed in this study. The structural model was estimated using AMOS 23 and the result is illustrated in Figure 4.1..

As shown in Figure 4.1, the structural model presents seven constructs with paths linked to Intention to use. Each path established between variables corresponds to a hypothesis which we intend to analyse if it is verified or not. Table 4.5 shows the p-values, which indicate the degree of significance of the correlation between two constructs measured, as well as the path coefficients (β) between variables and the statement whether the hypothesis is supported or not. For the relationship between two constructs to be considered statistically significant, the p-value must be lower than 0,05.

The results show that Perceived Behaviour Control positively influences Intention to use (β = 0,594; p-value < 0.001), confirming hypothesis 1 (H1). Subjective Norm Peers positively affected Intention to Use (β = 0,223; p-value = 0.003), unlike Subjective Norm Media (β = -0.047; p-value = 0.536), which was not statistically significant in predicting Intention to Use. Thus, hypothesis 2 (H2) is confirmed, while hypothesis 3 (H3) is rejected.

Hypothesis 4 (H4), which positively relates Price Value to Intention to Use (β = 0.079; p-value = 0.124), proves not to be supported as it is not statistically significant. Also, Perceived Risk (β = 0.040; p-value = 0.540) is statistically insignificant in predicting Intention to Use, disproving hypothesis 6 (H6). In relation to Environmental Concerns (β = 0.188; p-value = 0.005), it is proven that it positively influences Intention to Use, thus hypothesis 5 (H5) is confirmed. In contrast, hypothesis 7 (H7) which states that Sharing Propensity (β = 0.060; p-value = 0.224), positively influences Intention to Use, is not supported, given that this variable is not statistically significant.

In short, the results of the structural model evaluation support three hypotheses formulated in the proposed model, positive influence between the variables Perceived Behaviour Control, Subjective Norm Peers and Environmental Concerns with the Intention to Use. The remaining hypotheses were not supported.

Table 4.4. Model fit assessment.

Fit indices	Accepted thresholds	Model	Source
CMIN/DF	< 3,0	2,294	(Hair et al., 2009)
CFI	> 0,90	0,926	(Hair et al., 2009)
IFI	> 0,90	0,927	(Meyers et al., 2005)
AGFI	> 0,80	0,863	(Hair et al., 2009)
RMSEA	< 0,08	0,060	(Meyers et al., 2005)
SRMR	< 0,09	0,061	(Hair et al., 2009)

Table 4.5. Result of the hypothesis testing.

Hypothesis	Path	Path coefficient	p-value	Result
H1	PBC → IT	0,594	< 0,001	Supported
H2	SNP → IT	0,223	0,003	Supported
H3	SNM → IT	-0,047	0,536	Not supported
H4	PV → IT	0,079	0,124	Not supported
H5	EC → IT	0,188	0,005	Supported

H6	PR → IT	0,04	0,540	Not supported
H7	SP → IT	0,06	0,224	Not supported

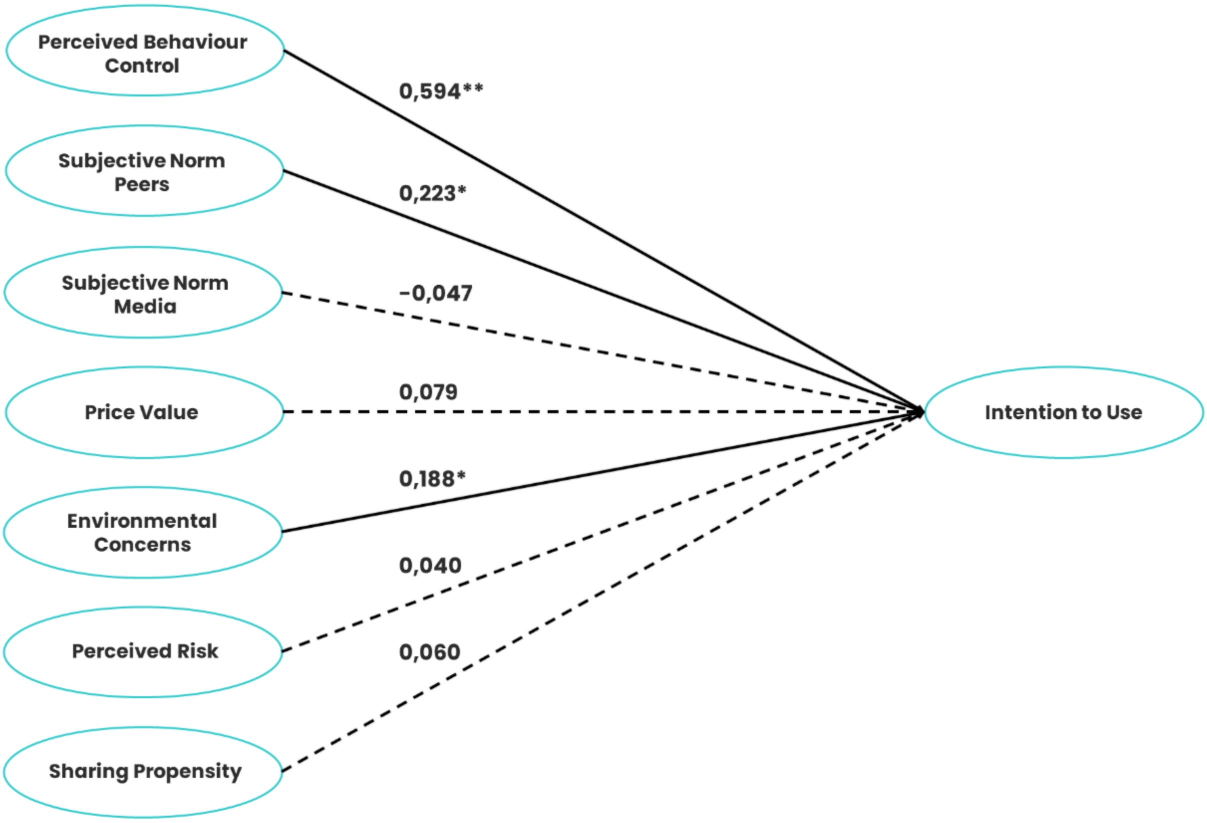

Figure 4.1. Results of the structural model. Notes: *p-value< 0,01, **p-value< 0,001; Dotted line represents insignificant path.

4.4. Multi-group Analysis

In order to enrich the investigation of this study, an attempt was made to analyse whether gender moderates the relationships explained in the hypotheses previously formulated when developing the theoretical model proposed in this work. Therefore, it was examined whether the path coefficients of the proposed model differ between different genders, male and female.

To obtain these results, a Multigroup analysis (MGA) was carried out, where the moderator is assumed to be a categorical variable, in this case, gender. According to Hair et al. (2017), MGA tests whether there are significant differences between predefined groups within the sample by determining path coefficients.

MGA was performed using AMOS 23 software, from which the invariance of the measurement model and structural model of the intention to use ESS in male and female individuals was analysed.

Firstly, the invariance of the measurement model was assessed in the two groups by comparing the unconstrained model (with factor weights and variances/covariances of the free factors) with a constrained model where the factor weights and variances/covariances of the two groups were fixed.

Then, the invariance of the structural model was assessed by comparing the model with free structural coefficients with the model with fixed and equal structural coefficients in both groups. To find out whether these two models differ significantly from each other, a chi-square test was performed according to Maroco (2014). As a result of the chi-square test done between the two models, a p-value of 0.000 was obtained, which means that the models are significantly different, i.e. there is a significant difference between the male and female groups.

Next, to test the moderating effect of gender in each hypothesized relationship, different chi-square difference tests were performed, where the two models (unconstrained and constrained) were freely estimated, with the exception of the one path to study the effect, to which the constraint of being equal across groups was applied.

The results of these chi-square difference tests, are exposed in Table 4.6. As can be seen, only two relationships showed a significant difference between the two models, considering that the chi-square threshold, with a 90% confidence interval is p-value <0.100. It is thus concluded that the relationship between the Perceived Risk construct and Intention to Use, as well as the relationship between the Environmental Concerns construct and Intention to Use, are different between males and females.

Although the previously described hypothesis H6 was not supported, there are significant differences between the results of the path coefficients between the genders. As shown in Table 4.7, while males have a path coefficient of 0.129, females have a path coefficient of -0.130. These results show that for females, Perceived Risk negatively influences Intention to Use, while for males this is not the case.

Furthermore, the results also show that the influence of Environmental Concerns on Intention to Use is positive and higher for men, with a path coefficient of 0.250, while for women it has a small negative influence, with a path coefficient of -0.053.

Table 4.6. Chi-square difference tests.

Path	Chi-square	df	p-value	Invariant?
PBC → IT	2,517	1	0,113	YES
SNP → IT	0,634	1	0,426	YES
SNM → IT	0,162	1	0,687	YES
PV → IT	0,004	1	0,950	YES
EC → IT	3,663	1	0,056	NO
PR → IT	4,116	1	0,042	NO
SP → IT	2,359	1	0,125	YES

Table 4.7. MGA results.

Path	Male	Female
EC → IT	0,250	-0,053
PR → IT	0,129	-0,130

4.5. Discussion of results and implications

The descriptive analysis of the data collected in the survey showed that 222 participants (62.4%) stated that they had already used e-scooter sharing systems, while 134 (37.6%) stated that they had never used these systems. These results are favourable towards the adherence of ESS. Regarding university students who reported having already used ESS, it was found that most of them make between 1 and 5 trips per month using these services. Thus, we conclude that ESS are more used for exceptional trips or recreational purposes than for daily commuting. The results show that most of the trips made are between 1 and 4 kilometres long, i.e. ESS are used for short trips. This result was expected, as e-scooter sharing systems are more suitable for short-distance trips.

This study aims to identify the factors that determine higher education students' intention to use e-scooter sharing systems. Therefore, from the evaluation of the structural model developed in this thesis, it was found that three of the formulated hypotheses were supported, these being H1, H2 and H5. While the remaining four, H3, H4, H6 and H7 were rejected, as they present a p-value greater than 0.05, thus being considered non-significant.

Analysing the results, it was found that Perceived Behaviour Control is the variable that most positively influences Intention to Use, presenting a path coefficient, i.e. a beta estimate of 0.594 (p-value < 0.001). Thus, hypothesis H1 is supported and the results obtained are similar to those for Eccarius & Lu (2020) and van Veldhoven et al. (2022), however, the measured effect is significantly larger than those reported in the mentioned articles. A high path coefficient between PBC and IU seems logical, as the perception of being able to unlock, drive and pay for the e-scooter sharing service is a basic requirement to trigger willingness to use ESS.

The second variable with the greatest positive influence on Intention to Use is Subjective Norm Peers, with a beta estimate value of 0.223 (p-value $= 0.003$). As in the de Fano et al. (2022) article, which inspired the addition of this construct to the developed model, the hypothesis H2 is supported and presents a path coefficient slightly higher than the one reported in the indicated study. This result suggests that the opinion, expectation and approval of the use of e-scooter sharing systems by the people most important to the individual, such as family, as well as by peers, is a major influence on the intention to use ESS.

Environmental Concerns denote the third variable with the greatest effect on Intention to use, presenting a beta estimate of 0.188. This indicates that EC positively influence Intention to Use, confirming hypothesis H5. These results demonstrate that college students perceive ESS as environmentally friendly and that using them fits with their environmental concerns. Similar evidence is found in Kopplin et al. (2021) study.

Hypothesis H4 was not supported (p-value > 0.05), not confirming a positive relationship between Price Value and Intention to Use e-scooter sharing systems. Similar to other studies, such as van Veldhoven et al. (2022) and Jahanshahi et al. (2020), Price Value was considered non-significant. However, in contrast to these studies, when analysing the path coefficient between PV and IU ($\beta = 0.079$), it is understood that although weak and non-significant, Price Value had a positive effect on Intention to Use. This small contrast can be attributed to the different location of the sample under study, considering that the price of ESS in Coimbra, Portugal is relatively affordable and sometimes can even be more economical than other public transport available in the city. Furthermore, it may also constitute a more convenient means of transport and offer shorter travel times.

The hypothesis H6 that determines the relationship between Perceived Risk and Intention to Use was rejected as it was considered non-significant (p-value > 0.05). Even so, when analysing the path coefficient between these variables, it was noted that it is positive and weak ($\beta = 0.040$), contrary to what would be expected based on the literature. In the articles by Y. Wang et al. (2020), which investigates the intention to use ridesharing services and by (Gao et al., 2019), which studies the adoption of bike-sharing systems, it was found that Perceived Risk has a negative relationship with Intention to Use. The result obtained in the present study may demonstrate a low perceived risk of the sample regarding ESS, which consequently does not negatively affect the intention to use these services.

Similarly to the previous case, the positive relationship between the variable Sharing Propensity and Intention to Use was found to be non-significant (p-value > 0.05), thus the hypothesis H7 was rejected. This result is not satisfactory, however, even though there are no previous studies in the literature investigating the relationship between SP and IU, Aguilera-García et al., 2022) reported that individuals with higher sharing propensity have more tendency to adopt carsharing services.

Last but not least, hypothesis H3 was not supported (p-value > 0.05), not confirming the positive relationship between Subjective Norm Media and Intention to Use. Although this hypothesis was rejected, it was observed that SNM has a weak and negative impact on Intention to Use ($\beta = -0.047$). Thus, the influence of social media on the intention to use ESS is not verified. In a study investigating the influence of SNM on intention to recycle plastic, de Fano et al. (2022) also reports a non-significant relationship, with the differential of the effect being positive.

Finally, a Multigroup analysis was carried out in order to investigate the moderating effect of gender on the proposed model. It was proved that the model presents significant differences between males and females and was therefore further analysed. It was concluded that gender moderates two relationships, Perceived Risk with Intention to Use and Environmental Concerns with Intention to Use.

Although the hypothesis H6 relating PR with IU was not supported, there are significant differences in the results of the path coefficients of this relationship which are relevant. While in males, Perceived Risk has a positive impact of 0.129 on Intention to use

ESS, the results show that for females, Perceived Risk negatively impacts Intention to use, with a path coefficient of -0.130. These findings show that females' risk perception has a negative influence on their intention to use ESS, while in the case of males this factor has a positive effect on their intention to use these services.

The results obtained in the MGA show that Environmental Concerns have a positive and more expressive influence on Intention to Use for males ($\beta = 0.250$), contrasting with the weak and negative impact ($\beta = -0.053$) of EC on IU for females. This indicates that somehow, factors related to e-scooter sharing systems such as their positive impact on urban traffic and being environmentally friendly do not positively affect females' intention to use these services. This result may be related to the fact that, in general, females are more consumerist than males, indirectly leading them to be more negligent towards environmental issues.

5. CONCLUSION

This study is among the few existing studies investigating the intention to use e-scooter sharing systems. As such, this study aimed to understand which factors affect the intention to use these services in the city of Coimbra, Portugal, as well as to find out what is the effect of gender on the intention to use ESS.

Based on two well-established technology acceptance and adoption theories, Theory of Planned Behaviour and Unified Theory of Acceptance and Use of Technology 2, a new model was developed. The proposed model aims to examine whether Perceived Behaviour Control, Subjective Norm Peers, Subjective Norm Media, Price Value, Environmental Concerns, Perceived Risk and Sharing Propensity can explain the intention to use ESS.

Although no effect was found between Perceived Risk, Subjective Norm Media, Sharing Propensity and Intention to use ESS, the theoretical horizons were still expanded by this study in the context of e-scooter sharing systems by the introduction of these new variables.

It was found that Perceived Behaviour Control is the variable that most impacts Intention to Use, followed by Subjective Norm Peers. In addition, Environmental Concerns also significantly and positively influence the intention to use e-scooter sharing services. However, not all variables under study proved to be able to predict Intention to Use ESS, such as Price Value, Perceived Risk, Sharing Propensity and Subjective Norm Media.

In addition, from a multigroup analysis, gender was found to have a moderating effect on the relationship between Perceived Risk and Intention to Use ESS, as well as on the relationship between Environmental Concerns and Intention to Use.

The results show that females' perceived risk negatively influences their intention to use e-scooter sharing services. As opposed to males who show a positive relationship between the variables Perceived Risk and Intention to Use.

As for the influence of Environmental Concerns on the Intention to Use ESS, it was observed that while for males they have a positive influence on the intention to use these services, for females the opposite is verified.

This work is expected to be useful for future studies on the intention to use e-scooter sharing, as well as other types of shared mobility, such as electric bikesharing.

In this thesis a new theoretical model has been conceptualized that may serve as a baseline for future research, and other researchers may modify or expand the model by adding new variables that have not yet been studied in the ESS setting.

In this study a multigroup analysis was carried out to study the moderating effect of gender, however, it would also be interesting to study in future work the effect of having or not having easy access to a motorized vehicle, as well as other variables.

Furthermore, this study is valuable considering the scarcity of studies on e-scooter sharing systems especially in the European context.

Finally, the fact that the sample consists only of college students may be a limitation of this study, as it does not cover perspectives from the entire population residing in the city of Coimbra, Portugal.

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APPENDIX A

Constructs	Items	Code	References
Perceived Behaviour Control		PBC	
	Eu acho que é bom usar sistemas de partilha de trotinetes elétricas.	PBC1	Han et al. (2017) and Si et al. (2020
	Eu acho que estou confiante em utilizar sistemas de partilha de trotinetes elétricas.	PBC2	Han et al. (2017) and Si et al. (2020
	Eu acho que tenho capacidade para usar sistemas de partilha de trotinetes elétricas.	PBC3	Han et al. (2017) and Si et al. (2020
Subjective Norm Peers		SNP	
	A maioria das pessoas que são importantes para mim pensam que eu deveria usar sistemas de partilha de trotinetes elétricas.	SNP1	Ajzen (1991), Tonglet et al. (2004), Kumar (2019)
	Os meus amigos/pares têm expectativa que eu utilize os sistemas de partilha de trotinetes elétricas.	SNP2	Ajzen (1991), Tonglet et al. (2004), Kumar (2019)
	A maioria das pessoas que são importantes para mim aprovam que eu utilize os sistemas de partilha de trotinetes elétricas.	SNP3	Ajzen (1991), Tonglet et al. (2004), Kumar (2019)
Subjective Norm Media		SNM	
	Os posts dos Social Media dão-me uma perspetiva positiva em relação à utilização dos sistemas de partilha de trotinetes elétricas.	SNM1	Moons and De Pelsmacker (2015)
	Artigos publicados nas redes sociais influenciaram-me a utilizar sistemas de partilha de trotinetes elétricas.	SNM2	Moons and De Pelsmacker (2015)
Price Value		PV	
	Eu acho que os sistemas de partilha de trotinetes elétricas têm um preço acessível.	PV1	(Jahanshahi et al., 2020)
	Eu considero que os sistemas de partilha de trotinetes elétricas oferecem um bom "value for money".	PV2	(Jahanshahi et al., 2020)
	Ao preço atual, eu acho que os sistemas de partilha de trotinetes elétricas são uma boa opção.	PV3	(Jahanshahi et al., 2020)
Intention to Use		IU	
	Se eu tiver acesso próximo a sistemas de partilha de trotinetes elétricas, vou utilizar.	IU1	(Eccarius and Lu, 2020)
	Eu estou disposto(a) a experimentar os sistemas de partilha de trotinetes elétricas.	IU2	(Eccarius and Lu, 2020)
	Eu estou disposto(a) a recomendar aos meus amigos e familiares a utilização dos sistemas de partilha de trotinetes elétricas.	IU3	(Eccarius and Lu, 2020)
Perceived Risk		PR	
	Eu considero arriscada a utilização dos sistemas de partilha de trotinetes elétricas.	PR1	(Gao et al., 2019)
	Eu acho que usar um sistema de partilha de trotinetes elétricas acrescenta incerteza à minha viagem.	PR2	(Gao et al., 2019)
	Eu acho que usar um sistema de partilha de trotinetes elétricas expõe-me a riscos acrescidos.	PR3	(Gao et al., 2019)
Environmental Concerns		EC	
	Eu acho que os sistemas de partilha de trotinetes elétricas têm um impacto positivo no tráfego urbano.	EC1	(Kopplin et al., 2021).
	Eu acredito que os sistemas de partilha de trotinetes elétricas ajudam a proteger o ambiente.	EC2	(Kopplin et al., 2021).
	Eu considero que a utilização de sistemas de partilha de trotinetes elétricas enquadra-se com as minhas preocupações ambientais.	EC3	(Kopplin et al., 2021).
Sharing Propensity		SP	

Eu estou disposto(a) a comprar produtos em segunda mão.	SP1	(Aguilera-García et al., 2022)
Eu estou disposto(a) a usar objetos que foram usados por outras pessoas antes de mim.	SP2	(Aguilera-García et al., 2022)