Enhancing User Acceptance of Automated Parking Systems in Thailand's Urban Low-Rise Household

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Abstract:

Automated parking systems (APS) have the potential to offer numerous benefits for low-rise housing developments, such as optimizing space, reducing emissions, saving time, improving land use efficiency, and enhancing security and safety. However, the successful implementation of APS relies on various factors, including the selection of appropriate technological components, careful design considerations, and addressing potential challenges and limitations. This study seeks to investigate and examine the main drivers and barriers that influence user acceptance of APS in Thailand's low-rise household sector. The study employs the Unified Theory of Acceptance and Use of Technology (UTAUT) model as its theoretical framework, while also incorporating additional factors specific to the context of low-rise housing and APS. The findings of this research are expected to provide valuable insights for real estate developers, policymakers, and stakeholders as they navigate the complexities and opportunities associated with integrating APS into Thailand's ever-changing real estate developments.

Keyword: Automated parking systems (APS), Low-rise housing, Real estate developer, User acceptance, Unified Theory of Acceptance and Use of Technology (UTAUT)

1. Introduction:

The rapid process of urbanization and population growth in Thailand has placed significant strain on the country's infrastructure, particularly in relation to urban mobility and parking facilities. In 2021, urban areas and cities were home to 52.16 percent of Thailand's overall population (Sereenonchai & Arunrat, 2022). The percentage of Thai population in urban areas and cities increase to 52.89 percent in year 2022 (O'Neill, 2022). As urban areas undergo continuous expansion, resulting in a surge of housing demand, real estate developers are actively investigating inventive approaches to maximize space utilization and improve the overall residential living experience. Concurrently, the number of cars and motorcycles in Thailand is steadily increasing due to economic development (Pongthanaisawan & Sorapipatana, 2010). According to the Thailand Department of Land Transport, the cumulative number of cars in Bangkok was 11,244,732 in December 2021 (Department of Land Transportation, 2023). The number of household in Bangkok was 3,147,231 in December 2021 (Administrative Strategy Division of Bangkok, 2021). Therefore, the average car per household in Bangkok was 3.5729 car per household. This surge in vehicle ownership has resulted in a shortage of parking spaces, consequently leading to congestion and traffic bottlenecks that adversely impact urban mobility. To address these challenges, the integration of automated parking systems presents a promising solution by optimizing land use and streamlining the parking process. Although the issue of congestion is often attributed to mismanaged on-street parking, Bangkok primarily relies on a parking prohibition on major roads as its predominant measure (Chullabodhi et al., 2022). When a vehicle is parked or stopped in a way that obstructs the flow of traffic, it may incur a fine of up to 500 Baht, according to this legal provision. By hindering the movement of traffic with any parked vehicle, individual are not only causing inconvenience but also committing a legal offense (Bhu-anantanondh et al., 2021). Additionally, it is crucial to consider traffic regulations as a key factor in this context. The Road Traffic Act B.E. 2522 (1979) (Krisdika.go.th, 2023), Article 397 (Thailand Law Library, 2023), and The Commercial and Civil Code 420, 450 (Thailand law online, 2023) are the primary regulations governing street parking.

The aim of this study is to investigate and analyze the key drivers and barriers that influence user acceptance of APS in Thailand's low-rise housing sector. In this context, the integration of automated parking systems into low-rise developments presents a promising avenue for addressing these challenges. The term "low-rise household" conventionally denotes residential structures comprising 1-4 stories, predominantly situated in residential areas, serving single-family or large family detached homes. However, it is noted that this study predominantly focuses on urban residential contexts.

Automated parking systems (APS) are becoming increasingly popular around the world. APS use a variety of technologies to park and retrieve vehicles without human intervention ("Automated Parking System," n.d.). This offers a number of advantages over traditional parking garages, such as increased efficiency, reduced space requirements, and enhanced security.

Fig. 1 Type of Automated parking systems that suitable for Low-rise household. (Smart Park Co. Ltd., 2024)

Automated parking systems, characterized by their efficient utilization of vertical space and reduced physical footprint compared to traditional parking garages (Stenger, 2022), have gained traction as a sustainable and space-saving solution for urban environments. These systems not only promise to alleviate parking congestion but also contribute to a more environmentally friendly and sustainable urban landscape. The scarcity of available land for construction in urban and rural areas, particularly in recent times, has transformed into a valuable and highly desired asset. Given the significant worldwide need for transportation, this has emerged as a critical concern that requires attention, leading to heightened traffic congestion and insufficient parking facilities. Numerous regions are grappling with parking shortages due to swift urban development and a rise in vehicle numbers, underscoring the importance of utilizing building land in a manner that enhances living standards through smart and effective parking solutions (Mikšíková et al., 2023). However, the successful adoption of such technology hinges on a critical factor: user acceptance.

User acceptance is a complex concept impacted by a multitude of factors such as perceived usefulness, ease of use, social influence, and facilitating conditions (Venkatesh et al., 2003). To effectively implement automated parking systems in low-rise real estate developments across Thailand, it is crucial to comprehend the dynamics of user acceptance within this specific context. This research aims to explore and analyze the key drivers and barriers that shape user acceptance of automated parking systems in Thailand's low-rise household sector. By investigating the applicability of user acceptance theories, such as the Unified Theory of Acceptance and Use of Technology (UTAUT), to the adoption of automated parking systems in low-rise housing, it seeks to identify the critical factors influencing user perceptions and attitudes toward these

innovative parking solutions and provide practical recommendations for enhancing user acceptance. The objectives of this study is to address the following:

1. To explore the various factors that impact user behavior on the adotion of APS in low-rise household.

2. To investigate the factors influencing behavioral intention for the acceptance of APS.

3. To study how gender, age, and recent&prospective number of cars in a low-rise household influence the behavioral intention to adopt APS.

In the subsequent sections, an examination of pertinent literature will be conducted, followed by an exploration of the theoretical framework that underpins this research. Additionally, a comprehensive account of the methodology employed to gather and analyze data will be provided. The idea of study is to bring clarity to the various factors that impact user acceptance within the context of low-rise housing adoption of automated parking systems. Ultimately, the discovering of this study are anticipated to offer valuable insights to real estate developers, policymakers, and stakeholders as they navigate the hurdles and prospects connected with the integration of automated parking systems in the ever-evolving landscape of Thailand's urban real estate developments.

Research Question

RQ1: What are the potential influences on user behavior regarding the adoption of APS in low-rise households?

RQ2: What are the key factors influencing residents' behavioral intention to adopt APS in low-rise households?

RQ3: To what extent do gender, age, and recent&prospective number of cars in the property influence the Behavior Intention for adopting APS?

2. Literature Review

2.1 **The Unified Theory of Acceptance and Use of Technology (UTAUT)** was developed by Viswanath V. (Venkatesh et al., 2003). The primary focus of this research is to investigate how usage behavior is impacted by behavioral intention. The study utilizes UTAUT to assess the uptake of novel products and technologies among prospective users (Schasché et al., 2022). Four primary determinants influence behavioral intention:

2.1.1.Performance Expectancy: The level to which a person has confidence in utilizing APS will easier their lifestyles. This encompasses the belief that APS usage eliminates the need to invest time in searching for parking spots, thereby saving valuable time. Additionally, it is associated with the notion that APS usage mitigates the risk of violating legal regulations and encountering potential violence.

2.1.2. Effort Expectancy: The perceived ease of use and usability of the APS. If a user believes the technology is easy to use, they are higher chance to adopt it.

2.1.3. Social Influence: The social influence construct in UTAUT does not focus on the real pressure to use the technology, but rather on the individual's perception of what other people they know believe they should do. The impact of social influence on an individual's decision to utilize APS. Specifically, this pertains to the perspectives and endorsements of acquaintances, peers, professional associates, net idol and counterparts.

2.1.4. Facilitating Conditions: The availability of resources and support necessary for using the APS, such as user manual, training, technical support, and infrastructure. This is including financial resources for each individual.

Furthermore, there are four moderator variables: age, gender, voluntariness of use and experience as shown in Fig. 2. These variables serve as extensions that enhance the preciseness of UTAUT's predictions. Several technology-focused studies have utilized UTAUT as their primary theoretical framework, including research on the willingness of South African drivers to adopt Autonomous Vehicles (Kettles & Van Belle, 2019) and the investigation of Demand-responsive transport services in rural areas (Schasché et al., 2022).

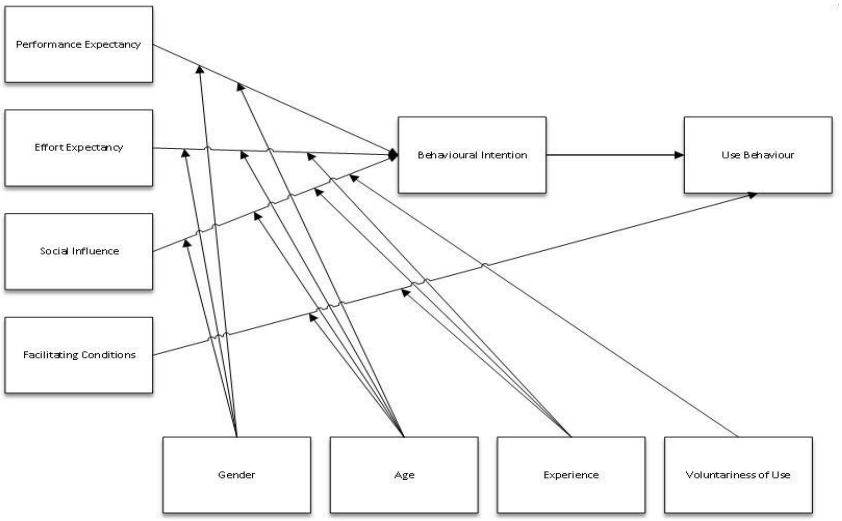

Fig. 2 Marikyan, D. & Papagiannidis, S. (2023) Unified Theory of Acceptance and Use of Technology: A review.

2.2. **Factors influencing acceptance of technology**

2.2.1 The acceptance of technology and usage behavior are based on 2 relevant factors as below:

1. Behavioral intention is a user intention to perform a certain behavior. It is a measure of how likely someone is to do something. This study explores the factors influencing the behavioral intention of individuals towards adopting APS in low-rise housing developments.

2. Facilitating conditions are the aspects in an individual's circumstance that make it easier or more difficult to perform a behavior. This study examines how environmental factors influence the ease of using APS in low-rise housing.

2.2.2 The six key constructs connect to behavioral intention shown in Fig. 3. (a diagram of proposed model) The previous study has utilized five factors (Sirikitsathian et al., 2017), however, this current study necessitates the inclusion of an additional factor(Facilitating conditions) in order to obtain more precise results.:

1. Performance expectancy is the extent to which a person has confidence in utilizing APS will help them achieve their goals.

2. Effort expectancy is the extent to which a person has confidence in utilizing APS will be easy to use.

3. Social influence is the procedure by which persons change their thoughts, emotions, or actions as a result of interaction with others.

4. Facilitating conditions are the determinants that affect its level of simplicity or complexity for people to adopt and use a new technology.

5. Perceived convenience is a user subjective assessment of how easy and effortless it is to use APS.

6. Perceived reliability is a user subjective assessment of how reliable APS.

Recent and prospective of car in the property, considering as moderator, is an auxiliary factor.

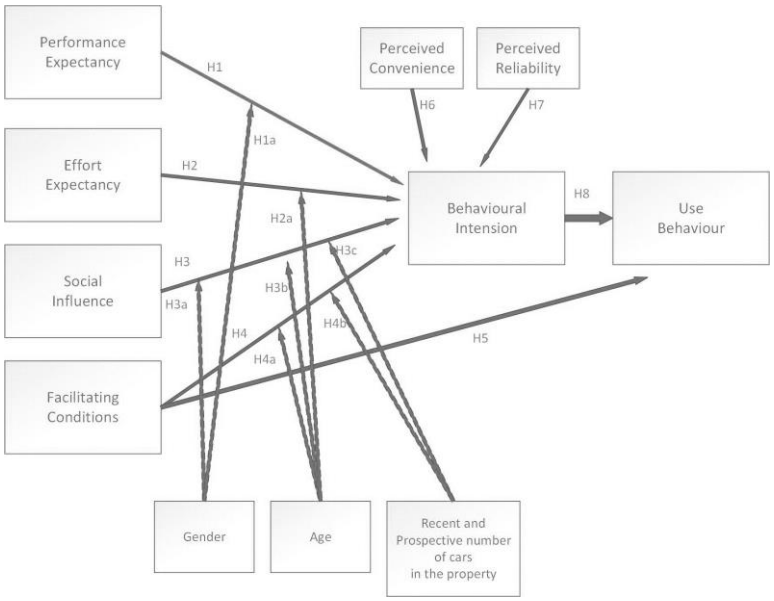

Fig. 3 Applied UTAUT for APS

2.2.3 Recent and prospective number of cars in the property

Recent and prospective number of cars in the household is an auxiliary factor (shown in Fig. 3). The number of cars in the property can moderate the relationship between the UTAUT constructs and user acceptance of APS. In properties with a high number of cars, the perceived benefits of APS (performance expectancy) may be stronger, as residents face greater challenges with traditional parking methods. The cars will be stacked vertically that traditional parking could not achieve (Global Market Size, Forcast, and Trend Highlights Over 2023-2035, n.d.). The household owners and property developers can assess the current and future parking demand, which can inform their decisions regarding the implementation of APS. The number of cars can also influence the cost-benefit analysis of APS adoption. In properties with a high number of cars, the potential savings in space and time may outweigh the initial investment costs, making APS a more attractive option. Based on the parking demand, APS implementation can be phased in gradually, starting with areas where parking congestion is most severe. This approach can help manage costs and allow for adjustments based on user feedback.

3. Proposed Framework

UTAUT is the main theory that craft the conceptual framework for studying user acceptance of APS in household in Thailand. In addition of 2 extra key factors, perceived convenience and perceived reliability, and 1 extra moderator, recent and prospective number of cars in property, the study will be more accuracy and predictable for the user acceptance.

The proposed framework fails to consider the influence of experience and voluntariness of use, as the former is determined by demographic factors beyond the scope of this study, and the latter is deemed inconsequential (Sirikitsathian et al., 2017). Nonetheless, in light of the study's context, a new moderator has been incorporated into the framework, namely, the recent and prospective number of cars in the property.

The ease of use APS, in this study in the aspect of performance expectancy (Sirikitsathian et al., 2017) is framed as hypotheses as below;

H1: Performance expectancy positively impacts the behavior intention to use APS.

The association between performance expectancy and usage intention/behavior are anticipated to be influenced by gender. The major car and technology adopter is male. Women accounted for less than 30 percent of electric vehicle purchases in the initial six months of 2021 (Kutz, 2022). More than 60% of new vehicle purchasers in the United States from September 2020 to August 2021 were male (Carlier, 2022). In UK year 2013 to 2015, male was tend to bought more car than female (Statista Research Department, 2015). Numerous research studies indicate that performance expectancy plays a crucial role in determining the continued use of technology over an extended period (Utomo et al., 2021). Therefore, we need to study further about this relationship.

H1a: The positive influence of performance expectancy on the behavior intention to use APS is moderated by gender.

It is anticipated that the level of attempt required to use the system will significantly impact the intention to use it in the early stages of system usage, but will have a lesser impact in later stages (Sirikitsathian et al., 2017). Ensuring that APS is user-friendly is predicted to have a substantial positive effect on APS users. Derived from this expectation, the below hypotheses are proposed.

H2: Effort expectancy positively impact the behavior intention to use APS.

A research paper examining the E-Banking Service in Iran discovered that performance expectancy, effort expectancy, social influence, and facilitating conditions all had a positive and significant impact on users' behavior and intention to use this type of service. Additionally, the variables of age and gender were found to moderate the relationships between these variables (Ghalandari, 2012). The age of the user exhibits an

inverse correlation with vision acuity, driving proficiency, and physical strenght. Consequently, the anticipation for APS of older drivers is to facilitate ease of use.

H2a: The positive influence of effort expectancy on the behavior intention to use APS is moderated by age.

The influence of social factors on behavioral intention within UTAUT is contingent upon various factors such as gender, age, and the recent and prospective number of cars in the property. A research paper was conducted to explore the impact of social influence on ICT adoption in the Palestinian Ministry of Higher Education (MOHE). The findings revealed that behavioral intention plays a positive role in mediating the relationship between social influence and ICT adoption. Additionally, it was observed that age acts as a negative moderator in the association between social influence and behavioral intention (Nassar et al., 2019)**.** The prevailing hypothesis in UTAUT concerning social influence can be articulated as follows:

H3: Social influence positively impact the behavior intention to use APS.

The gender variable may act as a moderating factor between social influence and user behavioral intention (Ghalandari, 2012). Gender especially male is emotionally affected by some net idol who are a car collector.

H3a: The positive influence of social influence on the behavior intention to use APS is moderated by gender.

The age variable may act as a moderating factor between social influence and user behavioral intention (Ghalandari, 2012). Individuals who are car collectors, businessmen, and homeowners form distinct social groups that provide recommendations to one another regarding lifestyle and trends. As a result, each age cohort exhibits a unique style.

H3b: The positive impact of social influence on the behavior intention to use APS is moderated by age.

The recent and prospective number of cars in the property will impact the decision regarding the adoption of APS, as the existing car garage is insufficient. In order to address this issue, individuals may resort to online research or seek advice from acquaintances on how to effectively manage their cars.

H3c: The positive impact of social influence on the behavior intention to use APS is moderated by the recent and prospective number of cars in the property.

According to Triandis (1980), the occurrence of positively intentioned behavior is impossible when there are FCs in the environment that hinder it (Hossain et al., 2017). The behavioral intention and facilitating conditions in this study is framed as hypotheses as below;

H4: Facilitating conditions positively influences the behavior intention to use APS.

The majority of users seeking an Automated Parking System (APS) are individuals who possess multiple vehicles but have limited garage space. This group of people has a good financial resource. The age-based classification of household data reveals a distinct pattern in annual expenditures and pretax income over the course of the life cycle. It follows a "hump" shape, with the lowest levels observed among the under 25 years group. Subsequently, both expenditures and income gradually increase, reaching their peak for the 45-54 age group. However, beyond this age group, both expenditures and income start to decline for the remaining groups (Foster, 2015). The demographic that saw the highest percentage of survey participants purchasing a new car fell within the 55 to 64 age range (Statista Research Department, 2015). The level of maturity directly influences the decision to adopt an APS.

H4a: The positive influence of facilitating conditions on the behavior intention to use APS is moderated by age.

In situations where the current car inventory exceeds the available parking space due to an increase in recent car acquisitions and the intention to purchase additional vehicles, it becomes imperative to seek appropriate facilities to accommodate the surplus automobiles.

H4b: The positive influence of facilitating conditions on the behavior intention to use APS is moderated by the recent and prospective number of cars in the property.

The occurrence of the behavior may be hindered if the facilitating conditions do not allow for it (Hossain et al., 2017). Therefore knowledge, training, technical support and user manual are key factors to learn the connection among facilitating conditions and use behavior.

H5: Facilitating conditions positively influences the use behavior to use APS.

The perceived worth plays a crucial role in determining satisfaction levels and subsequent behavioral intentions (Pham et al., 2018). The perceived convenience and reliability of the APS have a direct impact on usage behavior. As a result, these anticipations lead to the formulation of the following hypotheses.

H6: Perceived convenience positively impacts the behavior intention to use APS.

H7: Perceived reliability positively impacts the behavior intention to use APS.

A study examined how the mobile library application, system features, and interface features influence users' intention to use, while individual differences play a role as internal drivers of user behavior (Ming et al., 2021). The Behavioral intention is how likely someone is to do something and to impact individuals' inclination to embrace APS in low-rise housing developments.

H8: Behavioral intention positively influences the use behavior to use APS.

4. Conclusion and Discussion:

In a rapidly urbanizing environment like Thailand, where the demand for both residential housing spaces continues to surge, the challenges related to parking and urban mobility are becoming increasingly prominent. The integration of Automated Parking Systems (APS) presents a promising solution to these challenges, offering the potential to optimize land use, reduce congestion, and enhance overall urban sustainability.

This research proposal seeks to investigate and analyze the key drivers and barriers influencing user acceptance of APS within the unique context of Thailand's low-rise real estate developments. By utilizing the Unified Theory of Acceptance and Use of Technology (UTAUT) model and incorporating additional factors such as gender, age, and the recent and prospective number of cars in the property, this study seeks to illuminate the intricate dynamics of user acceptance.

By conducting surveys and focus group interviews, this research aspires to provide valuable insights that can inform real estate developers, policymakers, and other stakeholders. These insights will assist in navigating the complexities and opportunities associated with the integration of APS in Thailand's evolving urban real estate landscape.

This study aimed to identify factors influencing user behavior regarding the adoption of Automated Parking Systems (APS) in low-rise households. Participants highlighted common parking challenges such as limited space, difficulty maneuvering vehicles, and security concerns. They perceived APS as a potential

solution, offering increased convenience, improved security, and the potential to free up space for other purposes. Additionally, the study explored the influence of factors such as Performance expectancy, Effort expectancy, social influence, facilitating condition, convenience, and reliability on individuals' decisions to adopt APS. Further investigation is needed to determine the impact of gender, age, and recent&prospective number of cars on their behavior intention to accept APS in low-rise households.

In conclusion, as the urban landscape in Thailand continues to transform, understanding the factors influencing user acceptance of APS becomes crucial. This research, with its theoretical framework and methodological rigor, is poised to contribute to the knowledge base, offering practical recommendations and insights that can drive positive changes in the urban development and mobility sectors. The successful adoption of APS in this context not only promises to optimize parking but also to enhance the overall quality of life in Thailand cities, promoting sustainability, convenience, and efficiency

5. Limitations of the Study:

While the proposed research on user acceptance of Automated Parking Systems (APS) in Thailand's low-rise housing offers valuable insights, it's essential to acknowledge potential limitations:

First, this study focuses on urban of Thailand, which might not generalize to other countries with differing cultural contexts and regulations. The chosen survey and focus group participants might not fully represent the target population, potentially introducing bias.

Second, UTAUT might not capture all relevant factors influencing user acceptance in this specific context. Additional factors like trust in technology, privacy concerns, and cultural attitudes towards automation might need exploration. The chosen moderators (gender, age, car number) are relevant but might not encompass all potential influences. Consider including factors like income, technological experience, and parking challenges.

Third, APS technology rapidly evolves, findings might become outdated over time. Consider incorporating mechanisms for future updates and monitoring user perceptions.

Suggestion: In the future, additional research will be conducted to examine a wider range of target groups, including home offices and small offices, that may benefit from adopting APS due to limited parking space for their employees. The study will also delve into user acceptance across various housing types such as single-family homes and high-rise condominiums, as well as different demographics including

income levels and family structures, in order to identify specific needs and concerns. Furthermore, the acceptance of APS in other parking contexts such as commercial buildings, hospitals and event venues will be investigated, taking into account the unique challenges and opportunities presented in each of these settings. Future studies may investigate trust in technology by conducting surveys that assess perceptions of the safety and reliability of automated parking systems (APS). Additionally, culturally-specific attitudes towards automation can be explored through the utilization of focus groups or interviews. These qualitative methods can help gain insights into user comfort levels and concerns when it comes to entrusting parking tasks to technology.

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