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A Multi-Level Framework of Smart Transportation Adoption: A Systematic Literature Review of the Extended UTAUT2 Model using Weight Analysis

Yu Yang[1], Khalid, N.A*[2]

Abstract

Given the continuing global attention on smart transportation, the integration of mobile applications within smart transportation has become increasingly indispensable, not only in the realms of smart city governance but also mainstreamed across various Sustainable Development Goals (SDGs). The existing literature in this field, however, lacks a thorough examination of the various factors embedded in technology acceptance models and does not extend the context-specific variables in the model. Therefore, further academic attention is warranted. This systematic literature review (SLR) endeavours to bridge these gaps by categorising and systematising the existing literature, adopting the Extended Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) model as a framework within the context of smart transportation. Firstly, a weight analysis was used to discern the significance of each predictor and determine their interactions. Furthermore, this study addresses the impacts of various factors on users' behavioural intentions in this specific context across different themes (technological, personal, and environmental). Finally, the modified extended UTAUT2 was mapped to smart transportation context dimensions to identify the limitations of current technology adoption research and provide a multi-level framework for future research with a broad spectrum of context dimensions. Overall, the study contributes to the existing theoretical frameworks by providing valuable insights, new perspectives, and alternative possibilities for further exploration. Practical advice is also offered to policymakers and researchers seeking to improve the adoption and effectiveness of mobile applications in the dynamic landscape of smart transportation.

Keywords: *Smart Transportation, UTAUT2, Conceptual Framework, Weight Analysis, Systematic Literature Review*

1. Introduction

The rapid worldwide growth of information and communication technology (ICT) applications has made technology adoption a critical focus point in various areas of smart governance (Agboola, 2023). The successful implementation of this transformative phenomenon relies heavily on the widespread adoption and effective use of ICT applications by end-users (Alajmi, 2023), which has profoundly reshaped societal dynamics. The complexities associated with technology adoption extend beyond its technical aspects to encompass factors such as user attitudes, individual and performance-related advantages, social influence, enabling conditions, and other related factors. The adoption of technology is a mature research field in the current information systems (IS) literature (Dwivedi, 2019). Researchers are constantly striving to

[1]School of Social Sciences, Universiti Sains Malaysia, Penang, Malaysia. Email: yangziyu@student.usm.my
[2]School of Social Sciences, Universiti Sains Malaysia, Penang, Malaysia. Email: nurajrun@usm.my

comprehend the different factors affecting the individual's acceptance and use of the latest information technology (IT) (Skoumpopoulou, 2018). This has facilitated numerous and significant academic contributions to the progress of various user-behaviour theories and models, while technology adoption has been analysed in various systems and contexts.

Previous studies have identified new conceptual factors that influence user behaviour when technology is adopted (Nwaiwu et al., 2020). This extensive research has led to multiple methodologies being utilised to examine a wide range of technologies in different countries, revealing numerous theories, contexts, and units of analysis, as shown in Figure 1. The primary focus areas of these models, in chronological order, encompass the Diffusion of Innovation Theory (DIT) proposed by Everett Roger in 1960; the Theory of Reasoned Action (TRA) developed by Martin Fishbein and Ajzen in 1975; Social Cognitive Theory (SCT), proposed by Bandura in 1986; the Technology Adoption Model (TAM) introduced by Davis in 1989; the Theory of Planned Behaviour (TPB) developed by Icek Ajzen in 1991; the Motivation Model (MM) created by Davis, Bagozzi, and Warshaw in 1992; and the Extended Technology Adoption Model (TAM2) devised by Venkatesh and Davis in 2000.

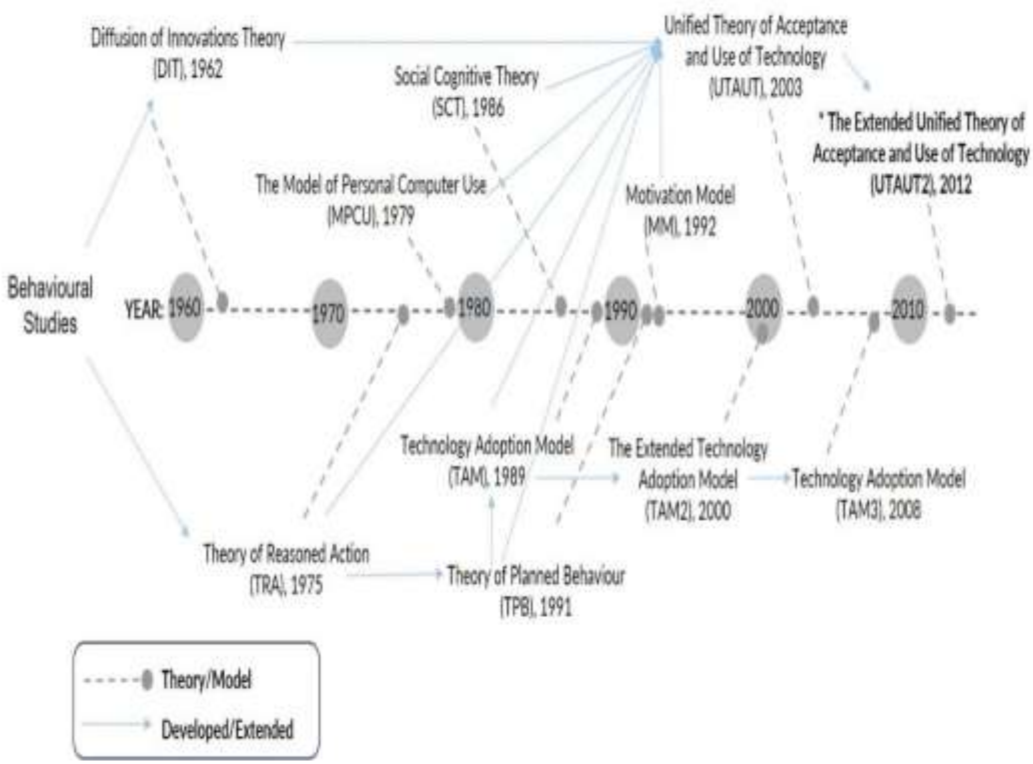

Figure 1: Chronology of the Progression of Technology Acceptance Theories.
Source: The Author's Work Based on Previous Studies.

Nevertheless, several different research settings influenced by factors such as technology (Rahimi et al., 2018), user traits (Venkatesh & Bala, 2008), geographical location (H.-K. Chen & Yan, 2019), adoption duration (Singh et al., 2022), and task execution have led to the emergence of numerous conflicting theories and models. Venkatesh et al. (2003) created a unified theory called the Unified Theory of Acceptance and Use of Technology (UTAUT) in the context of organisations. This theory was based on a thorough examination of eight prominent models of technology adoption. It emphasises the tangible value (external motivation) that users within organisations assign to technology, particularly after eliminating similar or redundant constructs. Moreover, the rise of consumer technologies required an expansion of the UTAUT model to encompass the user's context, highlighting the significance of hedonic value (intrinsic motivation) for technology users (Tamilmani et al., 2020). Thus, the original UTAUT model was extended to include three additional constructs: hedonic motivation, price value, and habit. This modified version, commonly known as UTAUT2, has far greater predictive effectiveness than UTAUT (Venkatesh et al., 2012). It can account for approximately 74% and 52% of the variation in consumers' behavioural intention and technology usage of the focal technology, respectively (Venkatesh et al., 2016).

The latest review from 2023 reveals that the extended UTAUT2 model had over 6,500 citations on Google Scholar alone, spanning the IS field. To date, it represents the most comprehensive research model in this field for understanding the myriad factors influencing user acceptance and utilisation of technological innovations (Tamilmani et al., 2020). Despite considerable scholarly attention being dedicated to domains such as user adoption of mobile banking (Motwani, 2016), mobile payments (Zhou, 2011), mobile healthcare (Meng et al., 2019), and mobile advertising (Salem et al., 2018), research is evidently lacking on user acceptance of mobile applications for smart transportation implemented by government initiatives. Additionally, analysis from various levels within this specific domain is conspicuously lacking. To effectively govern and encourage users to change their behaviour regarding the adoption of smart transportation applications, further research must be undertaken through a weight analysis of user acceptance of smart transportation mobile applications, with the extended UTAUT2 theory deployed to evaluate the cumulative performance of various predictors. The current authors also aimed to develop a multi-level framework that could guide future researchers while encompassing a wide range of contextual aspects. This systematic literature review (SLR) endeavours to address the following three research questions (RQ):

RQ1: What are the main categories of cited articles, based on the extended usage of the UTAUT2 model in smart transportation research?

RQ2: What level of weight is carried by each predictor that influences users' intentions to adopt mobile applications, and how do these predictors interact?

RQ3: How can the UTAUT2 extensions be synthesised with the particular context dimension to propose a comprehensive multi-level framework for assessing technology acceptance and use in future research?

2. Method

The SLR has developed into an established approach in the management field (Kraus, 2020). An SLR is used to define the scope of research and conduct an in-depth assessment of the existing literature in order to identify domains where further research is warranted (Sauer & Seuring, 2023). An SLR employs a rigorous methodology that ensures the transparency and reproducibility of the findings for future research (Seuring, 2020). To achieve the goals of conducting and structuring the research process, the four general stages described by Snyder (2019) were adopted and expanded: preparation, conduction, analysis, as well as structuring and writing a review. Figure 2 depicts the analytical framework employed during this study.

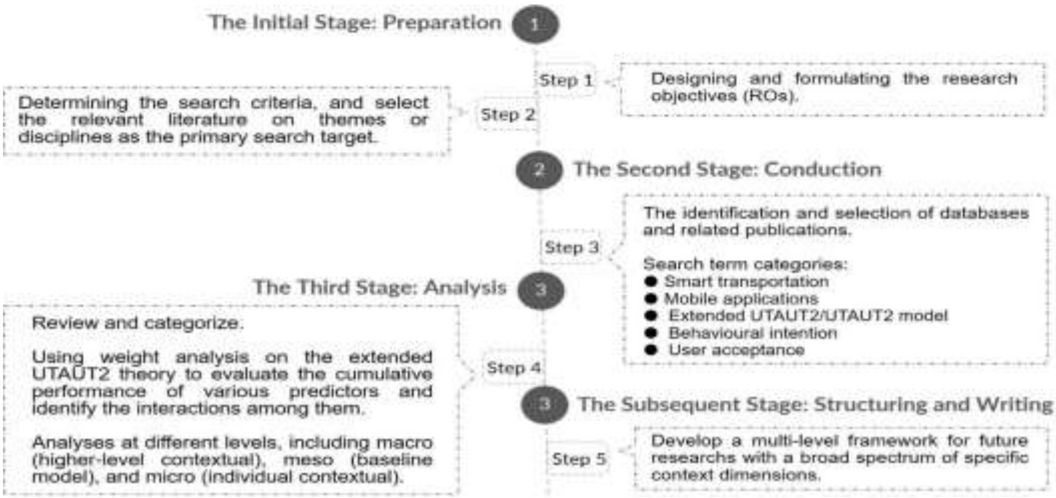

Figure 2: Analytical Framework for the Study
Source: The author's own categorisation.

Weight analysis was used to determine the influence of each predictor variable on an outcome variable. An evaluation was conducted of the correlation between the factors used in the selected literature to assess the adoption of smart transport. This specifically focused on variables like behavioural intention, attitude, performance expectancy, personal norms, user behaviour, and willingness to use. Having calculated the correlation coefficients, a cumulative value was estimated for each relationship. The weight analysis for all associations was performed by dividing the number of significant associations by the total number of associations.

2.1. The Preparation Stage

The initial stage of the research process involved two critical steps: first, designing and formulating the research objectives and, second, determining the search criteria. The former enabled the scope of the current review to be defined, while the latter established the protocol with which the review was conducted (Dhir, 2020).

2.1.1 Designing and Formulating the Research Objectives

In research endeavours, an SLR typically begins by establishing relevant RQs and research objectives (RO). Based on the previously mentioned RQs, three ROs were proposed to facilitate the analysis:

RO1: To comprehensively understand the major categories of cited articles pertaining to the use of the extended UTAUT2 model in research on smart transportation.

RO2: Using weight analysis, determine the significance of each predictor and the interactions between them.

RO3: To discuss the research gaps in the existing literature and synthesise the UTAUT2 extensions with the special context dimension to propose a multi-level framework for assessing technology acceptance and use in future research.

2.1.2 Determining the Search Criteria

The approach used in setting the criteria was to select a specific starting year between 2012 and 2023 for the search. This decision was made because the most recent model in this series (the extended UTAUT2) was introduced in 2012. The aim was to obtain an in-depth review of the advancements in the field. In addition, the authors primarily gathered peer-reviewed articles published in academic journals to ensure scientific rigour. Grey literature, which includes conference proceedings and popular publications, was excluded from the evaluation, as were books and book chapters since they tend to offer less systematic descriptions of the research method or lack empirical proof. Moreover, only international articles published in English were selected for this review because these publications have made substantial contributions to the global academic discourse.

Table 1: Eligibility Criteria Inclusion of Articles in the SLR.

Selection Criteria
1. Language: English only.
2. Journal: Peer-reviewed journals, which excluded grey literature such as popular publications.
3. Original research (including empirical and theoretical contributions).
4. Starting year for the search between 2012 and 2023.
5. Relevant to the research questions, with the following types of articles excluded:
* Not addressing user acceptance or behavioural intention;
* Not addressing mobile applications;
* Not addressing the extended UTAUT2/UTAUT2 models;
* Not specifically involving smart transportation;
* Addressing subjects related to user acceptance or behavioural intention but not smart transportation;
* Addressing subjects related to smart transportation but not using the extended UTAUT2;
* Addressing another context (such as health or social care);
6. Empirical and/or conceptual research.

2.2 Conducting the Search

The objectives of this study were to examine the correlation between measurements and outcomes by employing theoretical models referring to the extended UTAUT2 in the context of smart transportation and to develop a multi-level framework. The study article selection criteria were determined through a series of steps, as displayed in Figure 3.

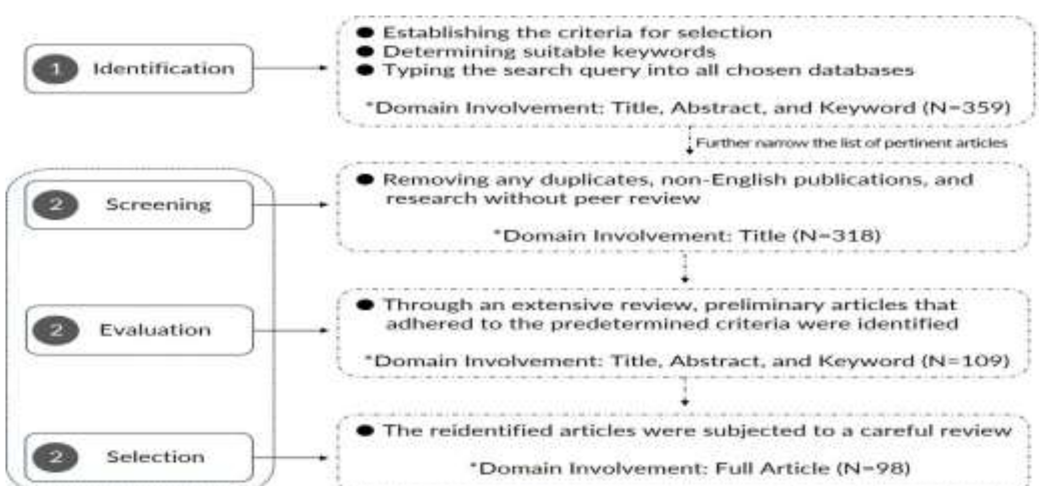

Figure 3: The Article Selection Process
Source: The author's own work.

Initially, the selection process involved identifying keywords suitable for conducting the literature review. The keywords chosen were "smart transportation", "mobile applications", "extended UTAUT2/UTAUT2 model", "behavioural intention", and "user acceptance". While first scanning the chosen databases, a query's sensitivity was extended by incorporating additional terms that appeared pertinent. The final search query was consistently employed across all the chosen databases. The keywords were used in databases such as Web of Science, Scopus, Springer Nature, and Emerald by deploying the logical operators AND and OR. A thorough examination of these databases revealed a total of 359 articles.

Subsequently, a triple-step procedure was utilised to further narrow the list of relevant articles that aligned with the established criteria for selection. Firstly, an evaluation was conducted of the sources and languages used in all the articles obtained from the search. This involved removing any duplicates, publications not in English, and research that had not undergone a peer review. After that, the titles and abstracts of articles pertaining to the research inquiries were extensively reviewed, and preliminary articles meeting the predetermined criteria were identified. Following the screening process, a total of 109 research papers remained. Ultimately, the preliminary set of reidentified articles underwent a careful review, which resulted in the exclusion of articles that did not meet the required standards. A total of 76 articles were extracted and considered to have adequately met the criteria at this stage.

2.3 The Analysis Stage

The analysis phase was conducted using a multi-step approach. Initially, all the chosen articles were thoroughly examined and classified according to their adherence to the extended UTAUT2 usage or a cited structure. This classification covered their empirical or conceptual research, positivist hypothesis testing, design research, and methods.

Secondly, weight analysis was used to determine the influence of a predictor variable on an outcome variable and illustrate the relationship between them. In addition, this study discusses how different factors influence users' behavioural intentions at different levels, including macro (higher-level contextual), meso (baseline model), and micro (individual contextual).

Finally, the modified version of the extended UTAUT2 model was applied to the dimensions of the smart transport context to pinpoint the limitations of existing technology adoption research and propose a multi-level framework for future research covering various context dimensions.

2.4 Structuring and Writing the Review

The final phase included structuring and producing the final review in alignment with the research objectives. This involved identification, analysis, synthesis, reporting, and proposing a multi-level framework for future research.

3. Research Profiling and Results

3.1. Categories for Citations of the Extended UTAUT2

To fulfil the aim of the study, an initial analysis, comparison, and classification were conducted of the extracted relevant information. Ultimately, all the selected articles were categorised into four main themes—citation, application, integration, and extension—with the specific aim of addressing RQ1. The classification was established by considering the use and role of the extended UTAUT2 framework in these articles. Table 2 provides detailed criteria and information pertaining to this classification.

Table 2: Extended UTAUT2 Citation Classification

Type	**1**	**2**	**3**	**4**
Theme	Citation(Foundational)	Application(Exploratory)	Integration(Exploratory)	Extension(Integrative)
Criterion/Rule	These types of articles pertain to theories of technology adoption or the use of research findings without substantially relying on the extended UTAUT2 theory.	These types of studies use empirical methods and focus solely on the extended UTAUT2 constructs or their moderators in their research model, either partially or entirely.	These types of studies encompass both empirical and conceptual research that combines components of the UTAUT2 theory, either partially or fully, with at least one other theory.	These types of studies refer to both empirical and conceptual research that uses UTAUT2 as a baseline model. Meanwhile, they extend this model by incorporating new exogenous, endogenous, moderation, mediation, outcome, internal, or external mechanisms.
Frequency	41	12	28 (21+7)	17 (15+2)
Total (N)	98 (89+9)			

3.1.1 Type 1: Extended UTAUT2 Citation

The citation with the extended UTAUT2 framework in the study was categorised as Type 1 and includes a total of 41 articles. Significantly, these studies differ from those in the other three categories due to their reduced theoretical application. In these types of research, the citations primarily reference UTAUT2 in the introductory sections, especially when discussing the development of widely recognised theories related to technology adoption. For example, Xu et al. (2018) included UTAUT2, along with other relevant theories on technology adoption, in their study of consumer acceptance of automated vehicles. In addition, some researchers not only referenced UTAUT2 in the introduction and findings sections but also employed the theory for hypothesis development and research design, such as Liu et al. (2022), who are cited for their examination of the factors influencing user acceptance of robo-taxi services. They also criticised the TAM and UTAUT2 in the future research directions section and justified their employment of the UTAUT2 model in a specific context.

3.1.2 Type 2: Extended UTAUT2 Application

A total of 12 articles were classified as application-related. The empirical studies examined the UTAUT2 constructs, either in their entirety or in part, along with their moderators. This emphasis indicates a heightened commitment to determining the intricacies and factors that influence the application of UTAUT2. Chen et al. (2020), for instance, employed a UTAUT2-based acceptance analysis model for driverless buses to investigate the corresponding influencing factors and offer an improved explanation of the public's acceptance intention regarding such buses.

3.1.3 Type 3: Extended UTAUT2 Integration

The integration theme encompasses a set of 21 empirical and seven conceptual studies. These integrate UTAUT2 with another theory of theoretical relevance, either entirely or partially, as an integral component of their research framework. By utilising an integrated model combining DIT, the TAM, and UTAUT2, Yuen et al. (2021) examined how variables affected users' behavioural intention to use autonomous vehicles (AVs). To evaluate the extent of public support for autonomous vehicles, Koh and Yuen (2023) applied the theory of computers as social actors and the extended UTAUT2.

3.1.4 Type 4: Extended UTAUT2 Extension

A set of 17 articles—15 empirical and two conceptual—comprised the integration type. Their primary distinction is that these studies utilised internal or external variables rather than theories derived from other sources; they also maintained some or all of UTAUT2 as a baseline model and employed new exogenous, endogenous, moderation, mediation, outcome, internal, or external mechanisms to incorporate external variables. One example is the extension of UTAUT2 by Kirana et al. (2023) to empirically study and analyse factors affecting electric motorcycle acceptance in Indonesia. The Extended UTAUT2 was also utilised by Saravanos et al. (2022) to determine whether end-users were willing to accept last-mile delivery services provided by autonomous vehicles.

3.1.5 Summary

The distribution across the four types reflects a delicate balance between foundational, exploratory, and integrative approaches to inquiry. Exploring the specific constructs and moderators that impact technology adoption within the extended UTAUT2 framework will deepen our understanding of the underlying mechanisms. Additionally, there is growing interest in combining UTAUT2 with other pertinent theories, indicating a trend of adopting holistic approaches to evaluating technology acceptance.

3.2. Weight Analysis

3.2.1 Defining Independent and Dependent Variables in Coding

This study employed a comprehensive coding system derived from the work of Jeyaraj et al. (2006) to systematically encode outcomes across multiple independent and dependent variables. The coding template was structured into "rows" and "columns", whereby each row corresponded to one of the 89 studies and each column represented the path relationship between an independent and a dependent variable. The intersections where studies align horizontally and path relationships align vertically indicate the importance of the specific path relationship associated with each study. The coding scheme included four distinct values: "+1", representing a significant and hypothesised positive path relationship; "−1", representing a significant and hypothesised negative path relationship; "0", representing insignificance; and "Blank", indicating that the relationship was not examined. A thorough analysis of 89 articles identified distinct relationship patterns between 45 independent variables and three dependent variables (see Table 3).

3.2.2 Smart Transportation Adoption Predictors and Results

Weight analysis was used to assess the significance of an individual variable. The vote-counting method was also employed, which calculates the frequency of a concept's use and the number of times it is statistically significant, thereby illustrating its relevance (Rhaiem, 2016). Of the 89 empirical articles chosen for analysis in the smart transport field, the focus was on examining the impact of a predictor (an independent variable) on the outcome (a dependent variable).

This analysis accommodated the evaluation of the predictive power of an independent variable (IV) in a specific relationship (Jeyaraj et al., 2006). Table 3 presents a comprehensive description of the 45 correlations commonly used in regard to the adoption of smart transportation. In the majority of studies, the dependent variable (DV) was behavioural intention (BI), which was used 39 times. The user behaviour (UB) and performance expectancy (PE) variables were each measured as DVs a total of three times.

Table 3: Weight Analysis Outcomes

No.	Independent Variable (DV)	Dependent Variable (IV)	Significant (a)	Non-significant	Total (b)	Weight (a/b)	*Type
1	Performance Expectancy	Behavioural Intention	35	2	37	0.95	BP
2	Attitude		32	1	33	0.97	BP
3	Facilitating Conditions		25	3	28	0.89	BP
4	Environmental Concerns		24	1	25	0.96	BP
5	Effort Expectancy		18	1	19	0.95	BP
6	Social Influence		18	3	21	0.86	BP
7	Environmental Benefits		18	1	19	0.95	BP
8	Hedonic Motivation		16	0	16	1	BP
9	Economic Benefits		14	1	15	0.93	BP
10	Subjective Norms		12	0	12	1	BP
11	Personal Norms		11	0	11	1	BP
12	Perceived Ease-of–Use		11	1	12	0.92	BP
13	Incentives		10	0	10	1	BP
14	Price Value		10	1	11	0.91	BP
15	Perceived Value		9	2	11	0.82	BP
16	Habit		9	0	9	1	BP
17	Perceived Knowledge		8	0	8	1	BP
18	Perceived Convenience		8	1	9	0.89	BP
19	Trust		7	0	7	1	BP
20	Innovativeness		7	1	8	0.86	BP
21	Psychological Benefits		6	0	6	1	BP
22	Subsidies		6	0	6	1	BP
23	Network Externalities		6	1	7	0.86	BP
24	Usage Experience		6	0	6	1	BP
25	Perceived Barriers		6	2	8	0.75	—
26	Personal Awareness		5	0	5	1	BP
27	Perceived Security		5	0	5	1	BP
28	Perceived Benefits		5	1	6	0.83	BP
29	Perceived Risk (-)		4	0	5	0.80	BP
30	Sustainable Behaviour		4	1	5	0.80	BP
31	Investment Risk		3	0	3	1	PP
32	Symbolic Attributes		2	1	3	0.67	—
33	Self-control Ability		2	0	2	1	PP
34	Ascription of Responsibility		2	0	2	1	PP
35	Instrumental Benefits		2	1	3	0.67	—
36	External Influences		1	0	1	1	PP
37	Lifestyle Compatibility		1	0	1	1	PP
38	Individual Mobility		1	0	1	1	PP
39	Perceived Enjoyment		0	1	1	0	—
Other DV							
40	Facilitating Conditions	Use Behaviour	6	0	6	1	BP
41	Behavioural Intention		5	0	5	1	BP

42	Willingness to Use		4	2	6	0.67	—
43	Effort Expectancy	Performance Expectancy	4	1	5	0.80	BP
44	Facilitating Conditions		4	0	4	1	PP
45	Costs		3	0	3	1	PP

Note: The abbreviations BP and PP stand for "best predictor" and "promising predictor", respectively.

The weight of one in Table 3 indicates that the association was significant in all the studies analysed, while a weight of zero implies that the association was not statistically significant in any of the studies. To identify the most effective predictors of adoption intention, Neves (2022) classified the measured variables into two categories: variables that had been analysed five or more times were deemed "well-utilised" and identified as "best predictors (BP). Meanwhile, variables that had been examined less than five times and had a weight of one were deemed "promising predictors (PP)". Furthermore, variable with a a weight above or equal to 0.8 that had been assessed at least five times were also classified as "BP". Of the 45 associations analysed in the weight analysis, 32 were identified as "BP" and eight were identified as "PP" for the smart transportation application. More specifically, when behavioural intention was the DV, the IVs in the study were hedonic motivation, subjective norms, personal norms, incentives, habits, perceived knowledge, trust, psychological benefits, subsidies, usage experience, personal awareness, and perceived security, all with a weight of 1 and therefore identified as "BP". When user behaviour was the DV, the IVs included facilitating conditions and behavioural intention; these are the two major factors with a weight of one that were also identified as "BP".

When the DV was behavioural intention, IVs with a weight of less than one and higher than or equal to 0.8 were identified as "BP". These included the following: performance expectancy, attitude, facilitating conditions, environmental concerns, effort expectancy, social influence, environmental benefits, economic benefits, perceived ease-of-use, price value, perceived value, perceived convenience, innovativeness, network externalities, perceived benefits, perceived risk, and sustainable behaviour. Furthermore, in the situation where user behaviour was the DV, a single IV - effort expectancy - was referred to as "BP" for smart transportation adoption.

The term "PP" encompassed factors like "investment risk, self-control ability, ascription of responsibility, external influences, lifestyle compatibility, and individual mobility" when behavioural intention was the DV. The "PP" among the IVs identified for smart transport adoption were "facilitating conditions and costs" when performance expectancy was the DV. Nevertheless, certain IVs that were utilised at least five times consistently produced insignificant outcomes, making them the least effective predictors of user behavioural intention to adopt smart transportation. These variables had a weight of less than 0.80. Less useful predictors may not necessarily attract well-utilised predictors with weights ranging from 0.50 to 0.80, such as perceived barriers (0.75) and willingness to use (0.68), which warrant further research in the future.

3.2.3 Drivers of the Critical Attribute

Figure 4 displays a sundial highlighting the predictors of the adoption of smart transport and their corresponding weights. Interestingly, none of the studies involved in this context had utilised the moderator of UTAUT2 relationships in its original form.

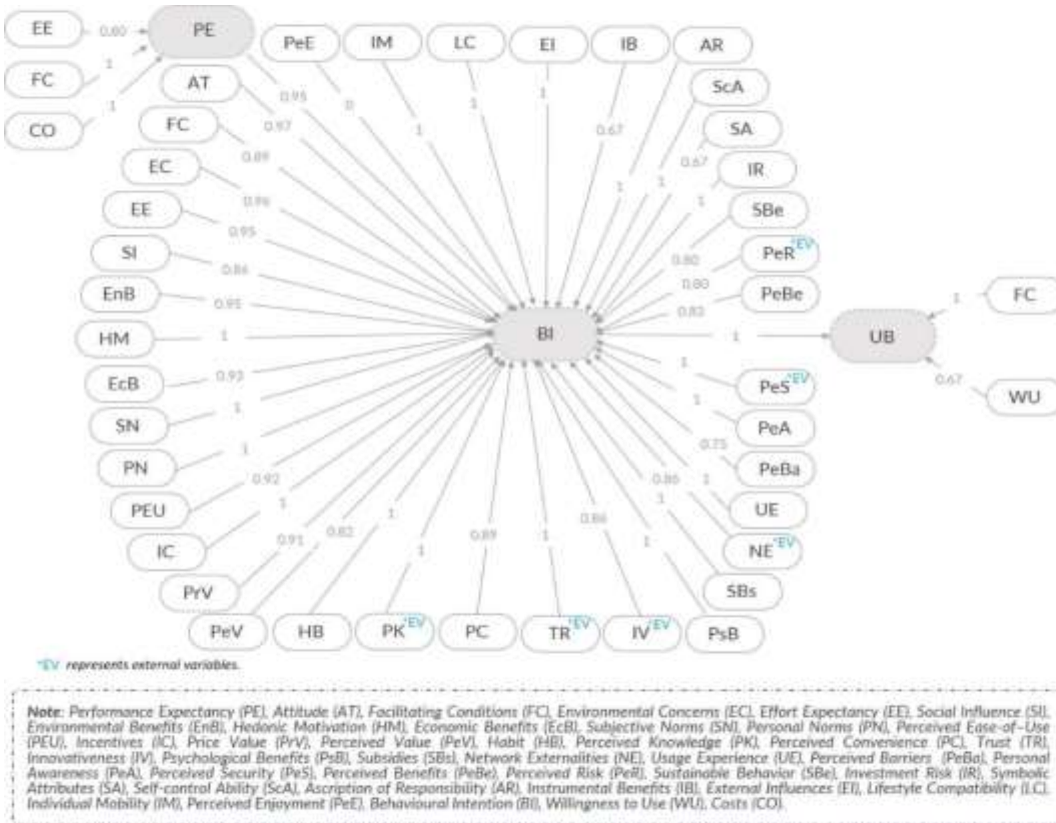

Figure 4: A Sundial of Predictors of the Adoption of Smart Transportation.
Source: The author's own work.

3.2.3.1 Findings for Outcome Variables in the Extended UTAUT2 Model

Apart from behavioural intention, which has been frequently researched, Figure 4 clearly displays two additional DVs - use behaviour and performance expectancy - in relation to the adoption of smart transportation. Three IVs in the study were employed to comprehend user behaviour regarding the adoption of smart transportation. Of these, facilitating conditions and behavioural intention were effectively utilised and demonstrated significant values on all six and five occasions (displayed in Table 3), respectively, and were therefore marked as “BP". Furthermore, when examining the adoption of smart transport, three IVs were also considered in relation to performance expectancy. Effort expectancy was examined five times, with significant results in four instances; facilitating conditions were examined four times, with significant results in all four instances; and costs were examined three times, with significant results in all three instances (see Table 3). Therefore, facilitating conditions and costs were identified as the primary independent variables among the multiple experimental variables examined; they were denoted as "PP" and had a weight of one.

3.2.3.2 Findings for External Variables

Of the 89 empirical studies, 21 were categorised as type 3, having an integration theme that utilised UTAUT2 constructs alongside external constructs or variables (EV) to explore user intention towards different forms of smart transportation adoption. Figure 4 displays the results of the analysis of the external variables, in which six distinct EVs were identified, as indicated by the blue words. Trust was the leading EV, having been employed in seven studies, while perceived risk and perceived security, the two most frequently utilised external constructs, were each used in three instances. Three additional external factors - perceived knowledge, network externalities, and innovativeness - were each utilised twice.

The hypothesis suggests a positive relationship between external factors and user behavioural intention, use behaviour, and performance expectancy in smart transportation adoption. However, the perceived risk variable, with a "(-)" sign (see Table 3), had a negative relationship with behavioural intention, indicating a negative path between the independent and dependent variables when examining user adoption of smart transportation.

3.2.4 Technological Personal Environmental (TPE) Mapping

Based on Table 3 and Figure 4, the correlations between the 45 driver factors illustrate that all 45 predictors were linked to three crucial conditions. These elements form a component of the technological-personal-environment framework in the context of adopting smart transportation. The additional areas depict the intersections between the domains of "personal and technological", "personal and environment", and "technological and environment". These intersections are illustrated in Figure 5, in which all the variables are represented using their respective abbreviations. RQ2 assumed a crucial place in this research, and it will be comprehensively addressed in detail by integrating the final section of this paper, which provides the necessary answers.

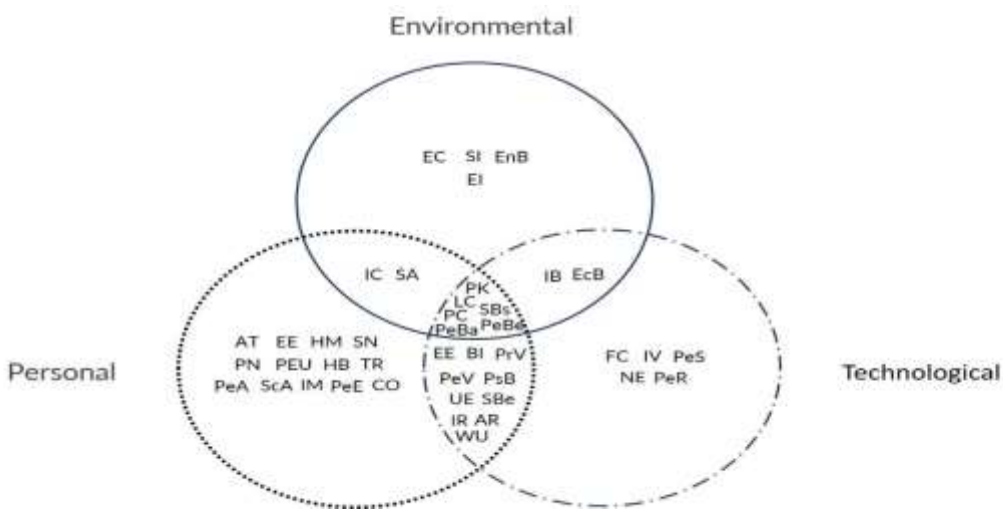

Figure 5: Impact Factors of Users' Behavioural Intentions and TPE Mapping.
Source: The author's Own Work.

According to detailed research, the personal factor is the most dominant in facilitating the adoption of smart transportation. It includes a total of 13 factors. The second most prominent factor is technological, which comprises a total of five factors. The "personal and technological" area contains ten distinct factors. Researchers usually employ environmental factors as a minor variable due to their site-specific nature, which renders them largely immutable. The four environmental factors encompass environmental concerns, social influence, environmental benefits, and external influences.

The development of technology, particularly in smart transport applications, can be extremely concerning due to five factors identified within the technological factor: facilitating conditions, innovativeness, perceived security, network externalities, and perceived risk. In addition to these five, there are ten other factors which, when combined with personal factors, include attitude, behavioural intention, price value, perceived value, psychological benefits, usage experience, sustainable behaviour, investment risk, ascription of responsibility, and willingness to use. Furthermore, the development of smart transport adoption accommodates six factors encompassing technological, personal, and environmental aspects. These six are perceived knowledge, lifestyle compatibility, perceived convenience, perceived barriers, subsidies, and perceived benefits. The development of these 21 factors is highly beneficial for advancements in technology, particularly in the mobile applications field, when it comes to the process of creating and improving services.

4. Multi-Level Framework: Mapping the Extended UTAUT2 Model

The integration of analysis and previous research contributions demonstrates that the UTAUT2 model specifically targets factors that impact individuals' intentions to accept and utilise a particular technology. While the models and theories have been extensively accepted in various contexts, their usage has been observed predominantly in developed countries. The UTAUT2 model has not been extensively studied in specific contexts such as smart city governance systems or in combination with complicated higher-level contextual attributes.

Therefore, the aim of this research was to develop and expand the UTAUT2 extensions, as well as the multi-level framework of technology acceptance and use formulated by Venkatesh et al. (2016), drawing upon Weber's (2012) theory of evaluation and a comprehensive examination of Johns' (2006) context dimensions. These were found to be relevant when addressing RQ3. The purpose of the partially simplified or added structure is to assist researchers in making context-dependent adjustments or omitting irrelevant constructs, compared to simply duplicating every construct in the underlying model or theory. Figure 6 illustrates the model derived from the synthesis of the UTAUT2 extension literature.

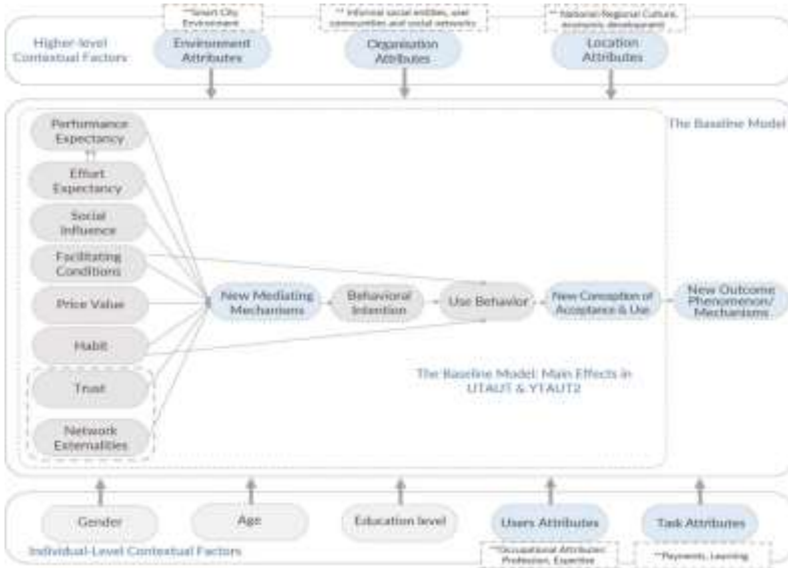

Figure 6: A Multi-level Framework of Technology Acceptance and Use.
Source: The author's own work based on previous studies (Derived from the Literature Review and Modified from the Work of Venkatesh et al. (2016)).

Note: 1. The bold arrows represent the main or new moderation effects (mechanisms) of contextual factors; 2. The blue dotted square represents the new exogenous constructs (mechanisms); 3. The blue boxes represent the significant areas for smart transportation adoption in future research on UTAUT2; 4. The main effects of UTAUT2 are represented by single arrows; 5. The double arrow represents the new main factor (variable) and developments derived from the literature review that extend the UTAUT2 model; 6. The white boxes with ** represent the reference variables that correspond to a particular context.

The structure of the multi-level framework model divides six of the seven exogenous constructs identified in UTAUT2 (PE, EE, SI, FC, PV, and HB) based on the technological, personal, and environmental categories. In other words, six exogenous constructs were retained and proposed for both behavioural intention and use as the central construct in the original UTAUT2 model. In addition to the previous dependent variables, certain exogenous variables of UTAUT2 were also mapped to the mediating variables. The variables listed above comprise the baseline UTAUT2 model, as depicted in the centre of Figure 6. The extension of the new outcome mechanism is enclosed by the dotted box. The comprehensive assessment of the use of the UTAUT2 theory in the context of smart transportation adoption revealed its shortcomings with regard to parsimony, which was mainly attributable to the intricate interactions of higher-order moderators. In this regard, the baseline model excludes individual-level contextual factors and moderation effects of age, gender, and education level, leaving only the main effects of UTAUT2 to be accounted for.

- The baseline model, which includes additional mediators and the UTAUT2 main effects, can be used as a foundation by future researchers to enhance the current context or investigate new contexts with parsimony.
- The contextual factors at the individual level are primarily addressed by the current UTAUT2 extensions, as illustrated in the lower part of Figure 6. This study consisted of UTAUT2 moderators, such as age and gender, as demographic attributes. Additionally, the

education level was added as a fixed basic user attribute and linked to the baseline model using bold arrows. Furthermore, this level extended the attributes of other user classes by incorporating the mapping of profession and expertise as occupational attributes. In addition to user attributes, task attributes played a significant role as individual-level contextual factors that facilitated different extension mechanisms. These included new exogenous, endogenous, moderating, outcome, mediating, external, and new internal mechanisms, all of which were incorporated into the UTAUT2 model as a baseline.

- The upper part of Figure 6 displays the higher-level contextual factors that offer potential for future research on specific contextual dimensions for UTAUT2 extension studies. These dimensions include environment attributes, organisation attributes, and location attributes. Although these have significant potential, none of the current UTAUT2 extensions have emphasised primarily the environmental and location attributes. Instead, the focus has been on the "why" heuristic, which presents numerous opportunities for future researchers. The organisational attributes, which include informal social entities, user communities, and social networks, as well as the location attributes, which include national culture and economic development, can act as higher-level contextual factors that influence individuals, as shown by the bold arrows in Figure 6. To consider location or organisation attributes as influential factors, future models require multi-sample and multi-location research to develop theories addressing the impact of these attributes.

5. Research Agenda for Future Directions

This section presents an extensive review of prospective research, commencing with an identification of the research gaps before offering valuable insights, new perspectives, and alternative suggestions for further research, as outlined in Table 4.

5.1 Identifying Research Gaps

- The analysis of UTAUT2 extensions revealed that most studies have introduced novelty by either adding or removing constructs and/or establishing new connections, with a focus on the existing main subject. However, no original contributions were made by exploring new main subjects or innovatively reconsidering the existing main subject.
- The results indicate that while the extended UTAUT2 theory has been frequently used in the field of technology acceptance and use, most studies only utilised a single theory. Few studies employed a combination of theories when examining the adoption of smart transportation.
- The results prove that the model does not accommodate several important non-technological factors, such as hedonic motivation, subjective norms, personal norms, incentives, habits, perceived knowledge, trust, psychological benefits, subsidies, usage experience, personal awareness, and perceived security, in addition to the traditional acceptance theories.
- Furthermore, the original UTAUT2 model includes no theoretical explanation of how it influences individual attributes like attitude, other than its role as a mediator between UTAUT exogenous variables and BI.

To summarise, future research should focus on developing the current specific context, exploring new focal phenomena and examining individual characteristics as new mediating attributes.

5.2 Further Agenda

Table 4: Overview of Prospective Research Domains.

NO.	Research Area/Gaps	Recommendations and Suggestions
1	Gaps in the Baseline Model	● Utilise UTAUT2 as a baseline for employing technical features to develop a new approach to individual technology acceptance and use. ● Incorporate non-technological exogenous variables into future research endeavours while maintaining UTAUT2 as the baseline model. ● To enhance its exploratory power, use UTAUT2 as a baseline to assess the acceptance of each individual technology, conduct research, and investigate individual characteristics as potential mediators.
2	Higher-Level Contextual Factor Gaps	● Expand the dimensions pertaining to environmental attributes, organisational attributes, and location attributes. Researchers should conduct research involving multiple samples and locations to develop theories about the influence of these attributes in their future research models.
3	Individual-Level Contextual Factor Gaps	● Expand user attributes and task attributes, in conjunction with individual-level contextual factors, to enable various extension mechanisms. These mechanisms propose the inclusion of new exogenous, endogenous, moderating, outcome, mediating, external, and internal mechanisms.
4	Mixed-Level (Whole) Contextual Factor Gaps	● Analyse the correlation between attributes of various classes, such as classes of individuals, as well as the higher-level attributes of classes, to integrate the expansion of newer environmental, organisational, and location attributes. Likewise, incorporate the relevance of higher-level attributes with the individual attributes of classes to expand the new user attributes and task attributes.

6. Conclusion

The main objective of this study was to provide an SLR concerning the extended UTAUT2 by using weight analysis in the specific context of adopting smart transportation. A further aim was to propose a multi-level framework tailored to the specific aspects associated with implementing smart transportation. To accomplish this objective, the authors extracted and evaluated a total of 98 relevant studies published between 2012 and 2023 to examine the adoption of smart transportation. This analysis aimed to enhance the overall comprehension of historical, current, and future research on technology adoption and utilisation.

Firstly, the process was identified from the foundational, exploratory stage to the final stage of integration, and the UTAUT2 literature was accurately classified into four types based on usage: citation, application, integration, and extensions. The UTAUT2 extensions, which demonstrate considerable potential for future researchers, can be divided into seven distinct categories: new exogenous, new endogenous, new moderating, new outcome, new mediating, new external, and new internal mechanisms. The Weber (2012) theory evaluation framework was subsequently employed to assess the UTAUT2 extensions of the current framework. The objective of this evaluation was to examine the scope and present condition of the UTAUT2 theory in relation to the adoption of smart transportation. The findings indicated that the UTAUT2 theory is of higher quality in most respects, yet certain limitations remain. These encompass factors like a lack of simplicity and ambiguous boundary conditions resulting from the model's intricacy. Subsequently, the UTAUT2 expansions were scrutinised by employing Johns' (2006) context dimension. Then, a multi-level framework was proposed that would specifically address the gaps in the current UTAUT2 expansion studies, such as the lack of consideration for environmental attributes in relation to smart transportation adoption. The framework was intended to align with the specific context of smart transportation adoption and bridge the existing gaps.

In conclusion, having integrated the findings from the assessment of the UTAUT2 theory and accommodated various contextual factors, potential avenues for future research were proposed, and a frame of reference for contextual information was offered. To enhance theory-based studies, it is important to identify and prioritise theories and frameworks that have demonstrated validity and that are sufficiently valuable for investigating the adoption of different smart government systems. This study provides robust support for researchers and presents a multi-level theoretical framework that can be used as a foundation to enhance individual acceptance models and for future research. It offers practitioners a helpful alternative perspective and will contribute to a better understanding of the main elements and connections between variables. This will enable researchers to design, improve, and implement mobile applications that can attain high user acceptance and strengthen the current levels of adoption. Moreover, practical guidance is provided to government policymakers seeking to enhance the implementation and efficacy of mobile applications in the dynamic realm of smart transportation.

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