PERCEPTION AND TECHNOLOGY ACCEPTANCE OF ELECTRIC CARS BY POTENTIAL USERS IN TÜRKİYE

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Abstract
In this study, the electric car technology perception and acceptance levels of potential electric car users in Türkiye were examined based on the modified Technology Acceptance Model 3 (TAM3). For this purpose, an initial research model suitable for the conditions of the study was designed and 12 hypotheses were created to test the relationships in the model. The research was carried out through an online questionnaire with 321 people who have never used electric cars. Since the survey results do not conform to the normal distribution, Partial Least Squares Structural Equation Modelling (PLS-SEM) method, which does not require normal distribution was used as the analysis method via SmartPLS 3 software. The compatibility of the proposed initial model was examined by evaluating the measurement model, structural model, and mediation effect. According to the analysis results obtained, gradual improvements were made on the model and a final model was reached. As a result of the compatibility analysis via fit indices, an acceptable model was obtained by reducing the initial 12 factors and 29 questions to 9 factors and 13 questions in the final model. According to the analysis results, it was determined that the Expected Ease of Use in the final model was the mediator.

TÜRKİYE'DEKİ POTANSİYEL KULLANICILAR TARAFINDAN ELEKTRİKLİ OTOMOBİL ALGISI VE TEKNOLOJİ KABULÜ

Anahtar Kelimeler
Teknoloji Kabul Modeli
Algı Anketi, Elektrikli Araçlar
Kısmî En Küçük Kareler (KEKK)
Yapısal Eşitlik Modeli (YEM)

Öz
Bu çalışmada, modifiye edilmiş Teknoloji Kabul Modeli 3 (TAM3) temel alınarak Türkiye'deki potansiyel elektrikli otomobil kullanıcılarının elektrikli otomobil teknolojisi algısı ve kabul düzeyleri incelenmiştir. Bu amaçla çalışmanın koşullarına uygun bir başlangıç araştırma modeli tasarlanmış ve modeldeki ilişkileri test etmek için 12 hipotez oluşturulmuştur. Araştırma, hiç elektrikli otomobil kullanmamış 321 kişi ile çevrimiçi bir anket yoluyla gerçekleştirilmiştir. Anket sonuçlarının normal dağılıma uymaması nedeniyle SmartPLS 3 yazılımı üzerinden analiz yöntemi olarak normal dağılım gerektirmeyen Kısmi En Küçük Kareler Yapısal Eşitlik Modellemesi (KEKK-YEM) yöntemi kullanılmıştır. Önerilen başlangıç modelinin uyumluluğu, ölçüm modeli, yapısal model ve aracılık etkisi değerlendirilerek incelenmiştir. Elde edilen analiz sonuçlarına göre model üzerinde kademeli iyileştirmeler yapılmış ve nihai bir modele ulaşılmıştır. Uyum indeksleri ile yapılan uyumluluk analizi sonucunda başlangıçtaki 12 faktör ve 29 soru nihai modelde 9 faktör ve 13 soruya indirilerek kabul edilebilir bir model elde edilmiştir. Analiz sonuçlarına göre nihai modelde Beklenen Kullanım Kolaylığının aracı olduğu belirlenmiştir.

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1. Introduction

The Technology Acceptance Model (TAM) suggests that when a new technology is offered to the users, there are a number of factors related to how they perceive and accept this technology, and it has been used in some studies in the literature.

However, TAM, which was originally put forward, has been updated and developed several times over time as it was insufficient to explain technology acceptance behaviors. As a matter of fact, Technology Acceptance Model 3 (TAM3) was proposed by Venkatesh and Bala in 2008.

The design, production, and factory installation efforts of domestic electric car, which is relatively a new technology in Türkiye, have started and still continuing as of 2022. The market is quite small and limited for today; however, it is estimated and planned that the market will grow very rapidly in Türkiye together with the introduction of domestic electric car brand as well as in countries such as China, Japan, Norway, the USA and Germany.

In this study, the perception and acceptance of electric cars as a new technology was measured and evaluated among potential users, namely those who are aware of these products but have not yet used them.

Determining the perception and acceptance level of electric car technology with this study, which was carried out in 2021 when electric cars were not widespread in Türkiye yet, will also give an opportunity to reveal the change after the technology becomes widespread.

For this purpose, the current study was based on TAM3 (Venkatesh and Bala, 2008), which is the most recently developed model in the literature, and it will be possible to measure and evaluate the differences by repeating a similar study a few years later. As a matter of fact, the domestic automobile brand called **TOGG** (Türkiye's Automobile Joint Venture Group Inc.), and some other foreign electric vehicle brands will be on the market to a certain extent and become widespread in the coming years.

According to the literature survey, it was observed that no similar study has been carried out in Türkiye yet, and this situation increases the importance of the current study even more.

An exemplary work in this field was carried out in Germany regarding the acceptance of electric cars for use in commercial vehicle fleets (Globisch, Dütschke and Schleich, 2018). In the study, the questionnaire prepared on electric cars and adapted from TAM3 was applied to people who already use electric cars, unlike this study.

Similarly, other studies have been conducted in China (Wu, Liao and Wang, 2020) and the Scandinavian region (Kester, Rubens, Sovacool and Noel, 2019) to measure the acceptance of electric cars in the society.

In this study, potential electric car users from among the public and a certain number of sector representatives were targeted. Because none of them were electric car users yet and it was thought that this would not be very important at this stage. Thus, before using the electric car, the level of perception and acceptance towards this technology was tried to be determined.

Statistical analyzes were made on the survey data prepared on a 7-point Likert scale, which was applied on 321 people from different segments of the society, either face-to-face or via internet with potential electric car users, based on TAM3. The obtained data was first analyzed and then SmartPLS 3 software tools. For this, statistical methods such as Reliability Test, Normality Test and Partial Least Squares Structural Equation Modeling (PLS-SEM) were used.

The questionnaire consists of two parts, and in the first part, 9 questions were asked to get to know the participants. The second part consists of 29 questions prepared directly within the scope of TAM3.

As a result of statistical analyzes, it was observed that the answers given by 321 people to the survey questions arranged according to the Likert scale were always skewed to the left, representing their positive opinions, and therefore the data did not fit the normal distribution.

At the stage of analysis and verification of the established initial model according to the Partial Least Squares Structural Equation Method (PLS-SEM), which does not require normal distribution, it is also essential to meet the compliance criteria required by the method. For this, the model was changed and improved by applying step-by-step reduction processes from both the survey questions and the factors, and thus the initial model took its final form.

2. Concept and Literature Survey

The Technology Acceptance Model (TAM) was first presented as a model proposal to test and develop user acceptance in computer-based information systems, to explain the reasons why people are resistant to the use of Information Technology (IT), and to reveal how they can react to technological changes (Davis, 1989). The aim of TAM was to provide a valid explanation for individuals' behaviors of accepting or not accepting Information Technologies and to express the factors that determine acceptance behavior in a relational plane (Davis, Bagozzi and Warshaw, 1989). However, this model was not found sufficient in time and was criticized and developed over time, and new model suggestions were presented by the researchers. Despite this, TAM has managed to become one of the most widely used models for explaining information technologies and for potential users to adopt new technologies (Venkatesh and Davis, 2000; King and He, 2006).

Technology Acceptance Model 2 (TAM2) was created by adding new factors to TAM (Venkatesh and Davis, 2000). In TAM2, constructs such as social effects and cognitive processes and experience have been added to explain Perceived Usefulness and Intention to Use.

The most frequently used extended technology acceptance model was the Unified Technology Acceptance and Use Model (UTAUT). In a study conducted by Venkatesh, Morris, Davis GB., Davis FD. in 2003, eight models that try to explain technology acceptance and use were discussed and their strengths and weaknesses were compared (Venkatesh et al., 2003). As a result of the study, the UTAUT was created as a new model, which was a synthesis of previous models (Zhou, Lu and Wang, 2010).

Unlike TAM, there are four exogenous variables in UTAUT as Performance Expectancy, Effort Expectancy, Social Impact and Facilitating Conditions, which are thought to have a significant impact on technology acceptance. In addition, Gender, Age, Experience and Voluntariness were seen as moderator variables influencing Behavioral Intention and Use Behavior.

The most widely used model in the adoption and use of Information Technologies is the Technology Acceptance Model (TAM). However, due to the lack of guidance for practitioners in TAM, as well as the low level of adoption and major barriers to the use of information technologies, the Technology Acceptance Model 3 (TAM3) research was initiated by Venkatesh and Bala as shown in Figure 1 below.

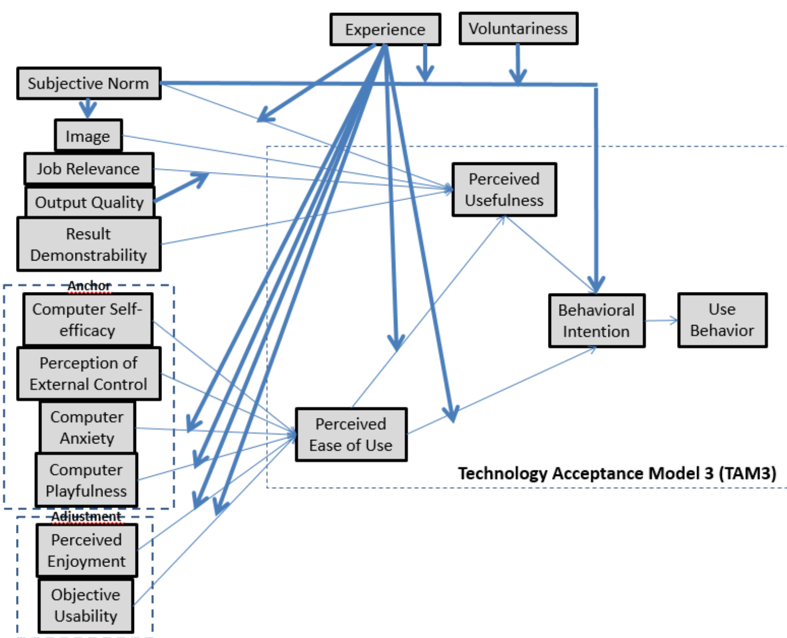

Figure 1 Technology Acceptance Model 3 (TAM3)

All factors in various Technology Acceptance Models are given comparatively in Table 1.

Table 1
Comparison of factors among technology acceptance models

TAM	TAM2	UTAUT	TAM3
Perceived Ease of Use	Perceived Ease of Use	Performance Expectancy	Perceived Ease of Use
Perceived Usefulness	Perceived Usefulness	Effort Expectancy	Perceived Usefulness
External Variables	Experience	Social Influence	Experience
Attitude Towards Use	Subjective Norm	Facilitating Conditions	Subjective Norm
Intention to Use	Behavioral Intention	Behavioral Intention	Behavioral Intention
Actual Usage	Voluntariness	Voluntariness of Use	Voluntariness
	Image	Gender	Image
	Output Quality	Age	Output Quality
	Job Relevance	Experience	Perception of External Control
	Usage Behavior	Use Behavior	Perceived Enjoyment
	Result Demonstrability		Objective Usability
			Job Relevance
			Use Behavior
			Result Demonstrability
			Computer Self-efficacy
			Computer Anxiety
			Computer Playfulness

In a study conducted in Germany, the antecedents of the acceptance of electric cars in commercial vehicle fleets were investigated based on TAM3.

In order to test the model created, a survey was conducted with 575 electric car users and the data using a 6-point Likert scale were analyzed using Structural Equation Modeling (SEM) through the AMOS package program. The empirical analysis took into account the preferences for electric car acceptance at both organizational and individual levels (Globisch et al., 2018).
According to the results obtained:

- More experienced electric car users charge their cars less and travel longer than less experienced users,
- The shortened range due to usage of heating systems in winter is the biggest obstacle to the use of electric cars,
- Employees' approaches to the use of electric cars are very important in supporting the acquisition of electric cars in commercial vehicle fleets,
- Environmental benefits and perceived ease of use in relation to the perception of car features are normally identified as precursors to electric car adoption. However, contrary to the results in the literature, the evaluation of the driving range of the cars in this study had a very low effect,
- Perceived Organizational Usefulness and Individual Usefulness were found to be effective in explaining support for electric car acquisition, whereas Perceived Organizational Usefulness was found to have a stronger effect.

In Figure 2, the Electric Vehicle (EV) fleet article model is compared with TAM3 model.

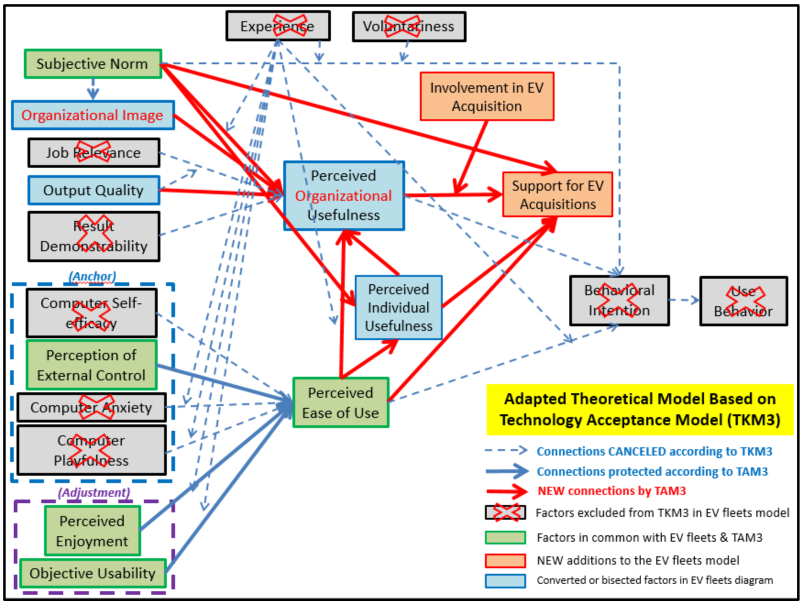

Figure 2 Comparison of EV Fleet and TAM3 Models

Factors with a red cross on represent factors removed from the EV fleet article model. The factors in the green boxes refer to the factors common to both models. The orange-colored boxes represent the new additions to the EV fleet model and the factors in the blue boxes represent the converted factors in the EV fleet model. The factors included are shown comparatively in Table 2 below.

Table 2
Comparison of factors in TAM3 and EV fleet models

TAM3 MODEL	**EV FLEET MODEL**
Perceived Ease of Use	Perceived Ease of Use
Perceived Usefulness	Perceived **Organizational** Usefulness
Experience	Perceived **Individual** Usefulness
Subjective Norm	Subjective Norm
Behavioral Intention	Involvement in EV Acquisition
Voluntariness	Support for EV Acquisitions
Image	**Organizational** Image
Output Quality	Output Quality **w.r.t Organizational Tasks**
Perception of External Control	Perception of External Control
Perceived Enjoyment	Perceived Enjoyment
Objective Usability	Objective Usability
Job Relevance	
Use Behavior	
Result Demonstrability	
Computer Self-efficacy	
Computer Anxiety	
Computer Playfulness	

3. Material and Methods

3.1 Partial Least Squares Structural Equation Modelling (PLS-SEM)

Structural equation models are a combination of multiple regression and factor analysis (Gefen, Straub and Boudreau, 2000) and are known as second generation multivariate analyzes due to their structure and computational technique. In SEM methods, beyond the first generation analysis techniques such as regression; principal component analysis, factor analysis, discriminant analysis or multivariate regression analysis are available. With these calculations, it is possible to reach versatile results and test the proposed theory and models (Gefen et al., 2000).

On the other hand, Partial Least Squares Structural Equation Modeling (PLS-SEM) is a statistical approach used for modeling complex multivariate relationships between observed and latent variables (Yılmaz, Can and Aras, 2019). PLS-SEM is seen as a soft modeling technique when compared to other statistical analyses. That is, in cases where it is difficult or impossible to meet the assumptions about the normal distribution required in multivariate statistics, it means that an easy model can be created with PLS-SEM (Vinzi, Trinchera and Amato, 2010). In addition, when the sample is large enough, good results are obtained with PLS-SEM despite lost or missing data (Hair, Hult, Ringle and Sarstedt, 2017).

There is no universally accepted goodness of fit index (GoF) in PLS-SEM. Therefore, model validity and fit are generally evaluated using factor loads, path coefficients, R^2, Q^2 statistics (Kline, 2011).

As a result of the examination of the Likert scale questionnaire data of 321 people, it was observed in this study that the data set obtained did not have a normal distribution and it was also determined that approximately 50% of the variables examined were kurtosis. This undesirable situation in the distribution limits the use of Structural Equation Modeling and Confirmatory Factor Analysis, which are statistical analysis methods in programs such as AMOS and LISREL. Therefore, PLS-SEM was used for analysis via SmartPLS 3 software.

The PLS-SEM method does not assume normal distribution and is accepted as a good approach for predictive analyzes (Henseler, Ringle and Sinkovics, 2009) and has gained popularity especially recently (Ringle, Sarstedt and Straub, 2012). It is appropriate to use PLS-SEM in studies where multivariate normality cannot be achieved and there are complex models with a large number of variables.

3.2 Sample Size

It is not possible to talk about a clear view in the literature about the required sample size. The reason for this is that the sample size required for the research can vary according to the complexity of the established model (Bowen and Guo, 2011). According to Kline, less than 100 samples are considered as insufficient, between 100 and 200 samples are considered as medium, and more than 200 samples are considered as sufficient (Kline, 2011). If a multivariate analysis is to be performed, the sample size should be 10 times or more than the number of factors (variables) in the study (Kerlinger, 1978; Hair, Anderson, Tatham and Black, 1998; Kline, 2011).

There are 12 factors in the initial model established in this study. Instead of 120, which is 10 times more, higher number of participants were obtained, and the number of survey data was collected as 321. In this case, it can be said that the minimum 200 sample size requirement specified by Kline is already exceeded.

3.3 Determination of Factors

TAM3 and EV fleet models were used as a basis for determining the factors for this study. As a result of the examination of previous studies, 12 factors were determined considering the content of the current study and the definitions of these factors as well as their definition sources are given in Table 3.

Table 3
Definition and sources of determined factors

No	Factor	Abbreviation	Definition	Source
1	**Subjective Norm**	**SNORM**	It is the degree to which an individual perceives that people who are important to him/her should or should not use the system.	Fishbein and Ajzen, 1975 Venkatesh and Davis, 2000
2	**Image** ***(By business or individual activities)***	**IMAGE**	It is the degree to which a person perceives that the use of innovation will increase his/her social status.	Moore and Benbasat, 1991
3	**Output Quality** ***(By business or individual activities)***	**OUTPUTQUALITY**	Output quality (in relation to organizational or individual tasks) is a general belief about how well an innovation will perform certain tasks.	Venkatesh and Davis, 2000 J.Globisch et al. 2018
4	**Expected Enjoyment**	**EENJOYMENT**	The degree to which the activity of a particular system to be used is expected to be enjoyable in and of itself, as well as the performance consequences resulting from using the system.	Venkatesh, 2000 Venkatesh and Bala 2008
5	**Perception of External Control**	**EXTCONTROL**	The degree to which an individual believes organizational and technical resources exist to support the use of the system.	Venkatesh et al., 2003
6	**Expected Organizational Usefulness**	**EORGUSEFULNESS**	It is the expectation of the extent to which the use of an innovation will improve organizational business performance.	Davis, 1989 J.Globisch et al. 2018
7	**Expected Individual Usefulness**	**EINDUSEFULNESS**	It is an individual's expectation of the extent to which the use of an innovation will improve his or her job performance.	Davis, 1989 J.Globisch et al. 2018
8	**Expected Ease of Use**	**EEASEOFUSE**	It reflects an individual's belief about the effort required to use an innovation.	Davis, 1989 J.Globisch et al. 2018
9	**Voluntariness**	**VOLUNTARINESS**	To distinguish between mandatory and voluntary use environments, the extent to which potential adopters perceive this adoption decision as unforced.	Hartwick and Barki 1994 Moore and Benbasat 1991
10	**Involvement in EV Acquisition**	**EVACQINVOLVEMENT**	Buying EV.	J.Globisch et al. 2018
11	**Support for EV Acquisitions**	**EVACQSUPPORT**	Supporting EV purchasing.	J.Globisch et al. 2018
12	**Behavioral Intention**	**BINTENTION**	It is a factor that drives people to use technology.	Venkatesh and Bala 2008

3.4 Research Model and Hypotheses

The initial model with 12 factors proposed for this study targeting potential electric car users in Türkiye is given in Figure 3.

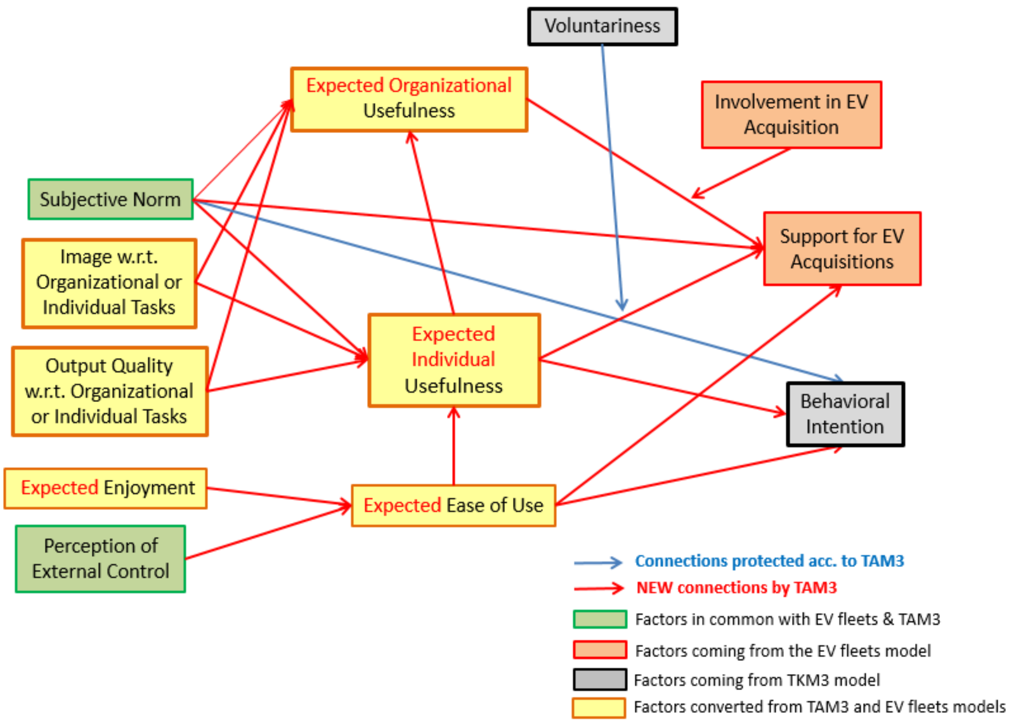

Figure 3 Proposed Initial Model

Green colored factors are common factors with EV fleet and TAM3 models. The orange-colored factors are from the EV fleet model; the gray-colored factors are from TAM3 model. The factors shown in yellow are the factors obtained by converting from TAM3 and EV fleet models specifically for this study. Since the study targets potential users not using the technology yet, the factors referred to as "Perceived" in TAM3 model have been converted to "Expected". Image and Output Quality factors, on the other hand, were comprehensively included in the model as organizational or individual activities.

The survey results were first checked to see if all variables were below the skewness and kurtosis values suggested by Kline (2011), and it was determined that the distribution of the data did not follow the normal distribution, as in Figure 4, and that the majority of them had a left skewed distribution.

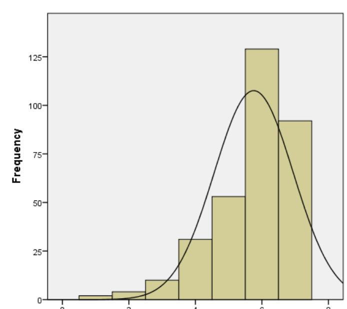

Figure 4 Question Q3 Normality Curve Histogram Graph

Since N>50 and the answers given in the test using Kolmogorov-Smirnov significance values do not have normal distribution, the hypothesis "*H0*: *The distribution is normal*" was rejected. Therefore, since programs such as AMOS and LISREL cannot be used, PLS-SEM method, which does not require normal distribution conditions, was used via SmartPLS software.

By loading the survey data into SmartPLS program, the first model designed was created as in Figure 5, and as a result of the analyzes, it was observed that the established model did not meet the compliance criteria for SmartPLS.

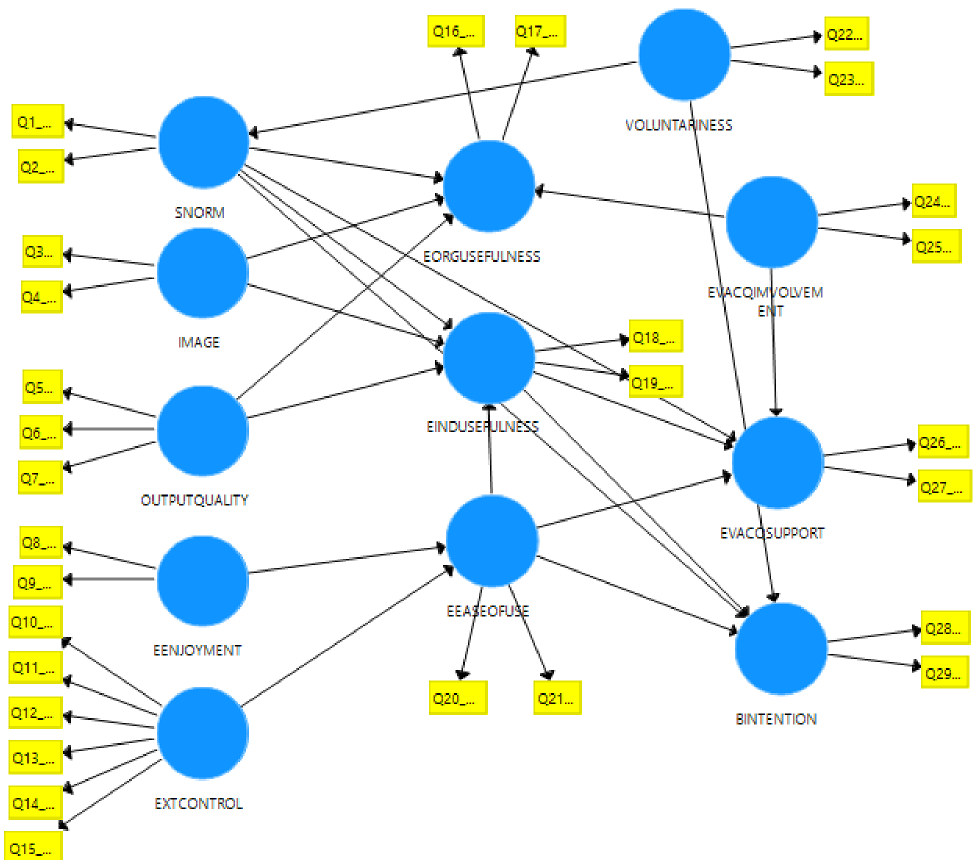

Figure 5 SmartPLS Representation of the Proposed Initial Model

For this reason, it was tried to obtain a model in which the necessary fit criteria were within reference ranges by making some changes sequentially. For this, the model was harmonized by applying the improvement steps given in Table 4, and while doing this, the principle that the model fully meets the SmartPLS compliance criteria, was considered.

Table 4
Step-by-Step changes for model improvement

Step	Improvements
1-11	Q14, Q15, Q22, Q29, Q19, Q24, Q10, Q5, Q7, Q11 and Q9 questions were deleted respectively.
12	Individual Usefulness and Organizational Usefulness were combined and made a single factor named as "**Expected Usefulness**".
13	The factor called **Support for EV Acquisitions** was removed.
14	The **Subjective Norm** factor was deleted.
15	A new relationship between **Image** and **Output Quality** factors was added.
16	A new relationship between **Expected Enjoyment** and **Expected Usefulness** was added.

The PLS-SEM method does not require a normal distribution condition, and it can produce results even in very small sample sizes and can work even when the factor in the model consists of a single expression (Çakır, F. S., 2019). For this reason, while making improvements on the model, the questions were first removed from the model in order to preserve the number of factors. The values of the compliance criteria were followed according to the required reference intervals and, improvements were made by applying them one by one and the results were rechecked each time.

Improvement decisions were made based on values automatically marked in red, indicating non-compliance by the SmartPLS program. Green values mean it is within reference limits.

After all these improvement steps in a total of 16 stages, the model took an intermediate form as shown in Figure 6 below.

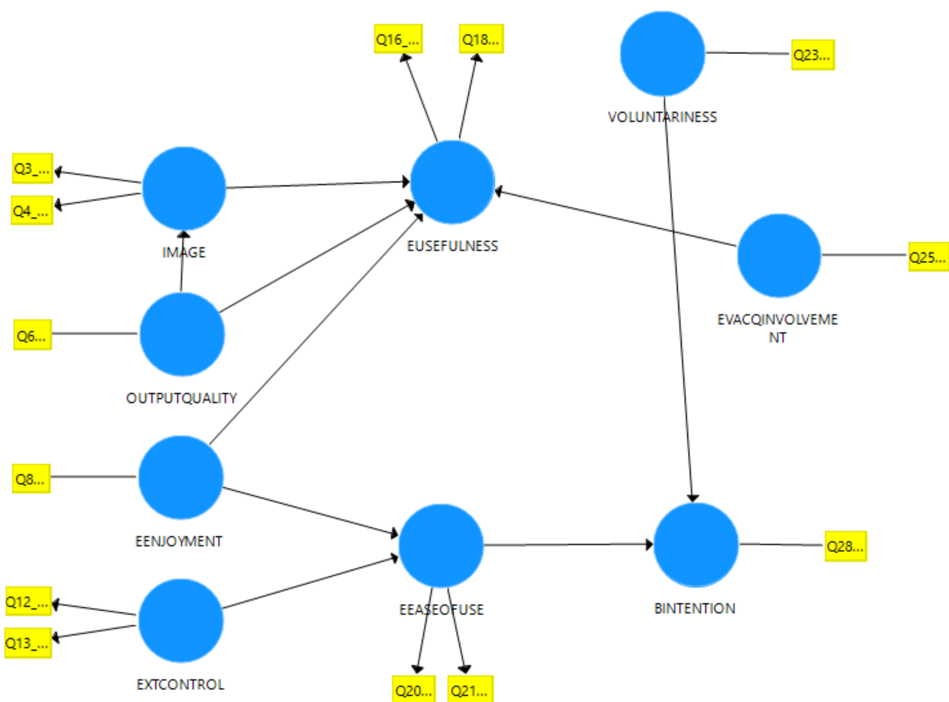

Figure 6 Intermediate Model in SmartPLS

The model gives values within the reference ranges of the required compliance criteria at this stage. From now on, the measurement model and structural model evaluations should be made on this intermediate model. As a result of the statistical analyzes in the SmartPLS 3 software, it was decided to accept or reject the hypotheses given in Figure 7 according to the p values with the 95% confidence interval (α=0.05).

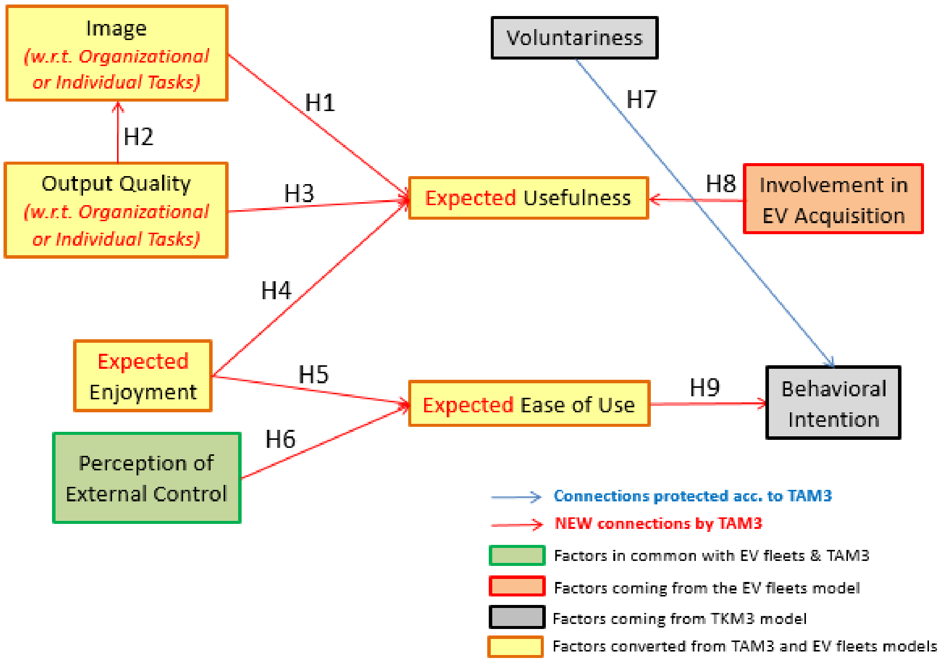

Figure 7 Representation of Hypotheses on the Model

The hypotheses established for the Path Model are as given in Table 5 below.

Table 5
Hypotheses for the path model

#	Hypothesis
H0	It is the common hypothesis representing that there is no relationship between any two factors.
H1	There is a relationship between Image and Expected Usefulness.
H2	There is a relationship between Output Quality and Image.
H3	There is a relationship between Output Quality and Expected Usefulness.
H4	There is a relationship between Expected Enjoyment and Expected Usefulness.
H5	There is a relationship between Expected Enjoyment and Expected Ease of Use.
H6	There is a relationship between Perception of External Control and Expected Ease of Use.
H7	There is a relationship between Voluntariness and Behavioral Intention.
H8	There is a relationship between Involvement in EV Acquisition and Expected Usefulness.
H9	There is a relationship between Expected Ease of Use and Behavioral Intention.

4. Results

4.1 Demographic Findings

The profile of the participants was analyzed with 9 questions in the first part of the questionnaire. Descriptive statistics is summarized in Table 6.

Table 6
Descriptive statistics

	N	Min. Value	Max Value	Mean Value	Standard Deviation	Variance
What is your gender?	321	1	2	1,57	,496	,246
What is your education level?	321	1	5	3,91	1,145	1,310
What range is your age?	321	1	5	2,72	1,293	1,673
What is your professional group?	321	1	6	3,33	1,774	3,147
Where are you working?	321	1	4	2,32	1,314	1,726
What settlement do you live in?	321	1	5	1,35	,718	,515
How is your financial situation?	321	1	5	3,47	,657	,431
In which region do you reside?	321	1	5	1,49	1,143	1,307
Do you know about electric cars?	321	1	5	2,81	1,072	1,150
N	321					

Due to being in the pandemic period, social distance and curfews have made it very difficult to conduct face-to-face surveys. Therefore 3.1% of the questionnaire was made face to face and 96.9% via internet. However, since the survey was conducted on the basis of potential users, this situation is not considered to be a big problem. 55.8% of the 321 participants were men and 44.2% women. 34.9% of the survey participants had ages 18 and above and the ages between 26-35 provided the highest participation. The 46-60 age group comprised the other majority with 22.7%. On the other hand, 77.3% of survey participants were higher education students.

The rate of those who had knowledge about electric cars was 55.1%, which was below expectations. Although the majority of the audience was young and educated, the lack of comprehensive knowledge about electric cars might be due to poor promotion or lack of interest. However, positive approach to electric cars refutes the second possibility and makes the first one more likely, as evidenced by the left-skewed survey results in line with the answers to the questions.

4.2 Evaluation of the Measurement Model

In order to perform Path Analysis, the proposed model must first obtain values within the reference ranges for the criteria specified in the following steps. The required values and the obtained values are listed below.

- First, Factor Analysis to test the construct validity of the model is to be made. Factor Loads should be >0.70 (Çakır, F. S., 2020). It was observed that factor loadings were between 0.7532-1,000, that is, all values were >0.70.

  Factor loadings express the weight of the variables (i.e. questions) in each factor. These values show the degree of relationship between variables and factors. If a variable has the strongest correlation to a factor, it means that it is the element of that factor (Nakip, 2003). As the factor load increases, it means that the variable and the factor are closely related (Altunışık, Coşkun, Bayraktaroğlu and Yıldırım, 2012). It can be said that if the factor load of a factor with a single variable, namely a question, is 1.000, then this variable and this factor are 100% correlated. Path coefficients are given in Figure 8.

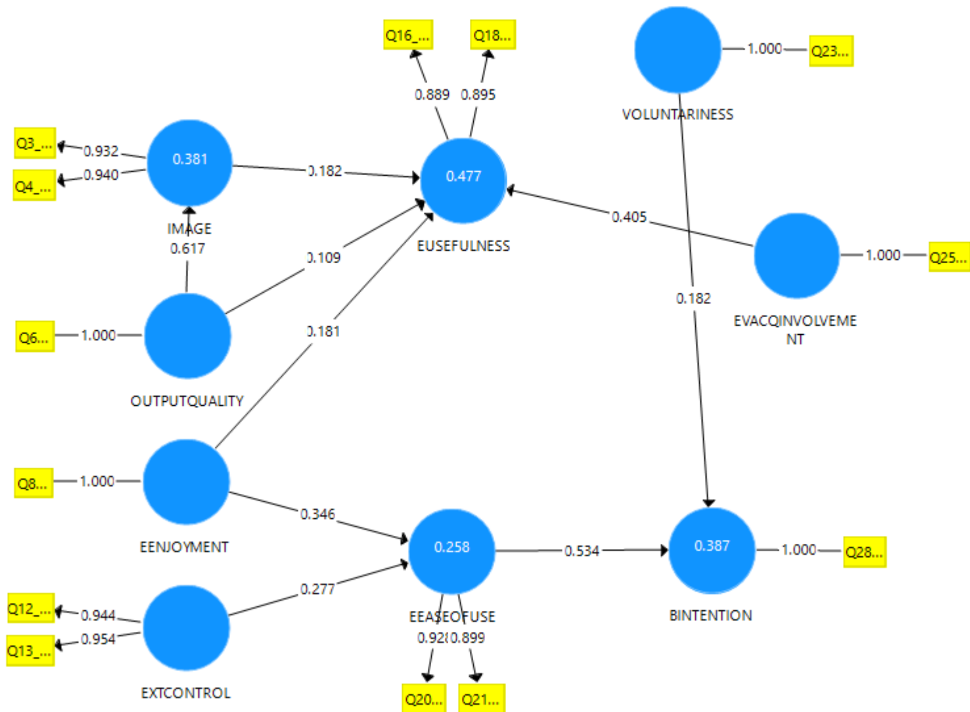

Figure 8 Path Coefficients and R^2 Values on the Intermediate Model

The t-test was used to test whether the relationships were statistically significant or not. The t-values obtained after bootstrapping of all path coefficients should be greater than 1.96 for 0.05 significance level (Çakır, 2020). It was seen that t-values were between 36,612-100,000 and path coefficients were between 0.887-1,000 i.e., all values were acceptable.

- In addition to the criteria given in Table 7 for reliability, the CR values should also be greater than the AVE values (Çakır, 2020). It was seen that all values were suitable for the reliability criteria.

Table 7
Reliability values

	Cronbach's Alpha (>0,50)	rho_A (>0,70)	Composite Reliability (CR) (>0,70)	AVE (>0,50) (CR>AVE)
EEASEOFUSE	0,8022	0,8165	0,8073	0,6782
EENJOYMENT	1,0000	1,0000	1,0000	1,0000
OUTPUTQUALITY	1,0000	1,0000	1,0000	1,0000
EXTCONTROL	0,8892	0,8954	0,8914	0,8044
BINTENTION	1,0000	1,0000	1,0000	1,0000
EVACQINVOLVEMENT	1,0000	1,0000	1,0000	1,0000
VOLUNTARINESS	1,0000	1,0000	1,0000	1,0000
IMAGE	0,8592	0,8614	0,8600	0,7545
EUSEFULNESS	0,7430	0,7439	0,7433	0,5916

- The R^2 value, which shows how much the latent variables explain the change in each other, should be above 0.26 (Çakır, 2020). The R^2 values are written in the latent variables that are explained in the model (i.e., the factors that get arrows) in SmartPLS. R^2 values are given in Table 8 and all values are suitable.

Table 8
R^2 values

	R^2 (>0,26)	*Corrected* R^2
EEASEOFUSE	0,3267	0,3225
BINTENTION	0,4538	0,4504
IMAGE	0,4425	0,4408
EUSEFULNESS	0,6495	0,6451

- Multicollinearity VIF values were in the range of 1,000-2.7845 for all questions. This value should normally be below 3 and any VIF value >10 indicates a large multi-collinearity problem in the model (Çakır, 2020).
- The Fornell-Larcker criterion is a widely interpreted criterion in PLS-SEM analysis and controls the discriminant validity. While interpreting this criterion, all values in rows and columns are considered. If a factor is compared with itself, the value obtained should be greater than all values in the same column and same row of the table (Fornell and Larcker, 1981). This shows how far the factors differ from each other and how they represent the model, and it was confirmed in the relevant matrix that this condition was also met for all factors.
- Another criterion, the HTMT value, should be <0.90. HTMT values varied between 0.2173-0.6949 for all factors and satisfies the relevant criteria.
- Cross Loadings give factor loads of all factors and variables together. The values of all variables under the factor column to which they belong should be the largest value in that column (Çakır, 2020). In this way, it is proved that the factors are separated by their own variables. The discriminant validity of the model is also ensured. In other words, it is interpreted that each question is related to its own factor in the proposed model. Cross Loading values are given in Table 9 as bold under their respective factors.

Table 9
Cross loading values

?	EEASEOFUSE	EENJOYMENT	OUTPUTQUALITY	EXTCONTROL	BINTENTION	EVACQINVOLVEMENT	VOLUNTARINESS	IMAGE	EUSEFULNESS
Q12	0,3487	0,3093	0,3707	**0,9435**	0,3399	0,3279	0,1826	0,4219	0,4629
Q13	0,3847	0,2960	0,3725	**0,9539**	0,3525	0,3278	0,2063	0,4361	0,4083
Q16	0,4877	0,3736	0,4483	0,4195	0,5275	0,5214	0,2701	0,4877	**0,8872**
Q18	0,4493	0,4540	0,4200	0,3973	0,5382	0,5471	0,2167	0,4630	**0,8966**
Q20	**0,9275**	0,4296	0,3384	0,3772	0,5865	0,4607	0,2946	0,3888	0,5285
Q21	**0,8987**	0,3591	0,2906	0,3271	0,5015	0,3735	0,3568	0,3321	0,4227
Q23	0,3535	0,2276	0,3322	0,2055	0,3710	0,4030	**1,0000**	0,3280	0,2723
Q25	0,4601	0,3376	0,4520	0,3455	0,6790	**1,0000**	0,4030	0,4605	0,5993
Q28	0,5987	0,3508	0,4085	0,3652	**1,0000**	0,6790	0,3710	0,5092	0,5975
Q3	0,3679	0,4510	0,5545	0,4418	0,4818	0,4124	0,3333	**0,9322**	0,4896
Q4	0,3748	0,5476	0,6003	0,4065	0,4720	0,4489	0,2824	**0,9402**	0,5074
Q6	0,3461	0,4537	**1,0000**	0,3916	0,4085	0,4520	0,3322	0,6174	0,4864
Q8	0,4344	**1,0000**	0,4537	0,3186	0,3508	0,3376	0,2276	0,5348	0,4649

- Among the fit indices, NFI should be > 0.90 and SRMR should be <0.08 (Çakır, 2020). Model Fit values are given in Table 10, and they seem to be suitable.

Table 10
Model fit values

SRMR (<0,08)	0,0209
d_ULS	0,0398
d_G	0,0326
Chi-Square	54,5462
NFI (>0,90)	0,975

- For testing model validity, the GoF index value is calculated by the mean of the R^2's and the geometric mean of the mean of the AVE's. A GoF value > 0.36 is an indication of good fit (Yılmaz and Kinaş, 2020). Since the program does not give this value directly, it was calculated separately.

  The GoF index takes values between 0 and 1. The degree of fit of the GoF index is low if GoF<0.1, moderate if GoF<0.25, and very good GoF>0.36 (Wetzels, Schröder and Oppen, 2009).

  The GoF index is obtained by taking the square root of the product of the mean of the AVE and R^2 values obtained for the factors. Its equation is given in Eqn. 4.1 below.

$$GoF = \sqrt{Ort(R^2) \times Ort(AVE)} \tag{4.1}$$

Ort(R^2)=1,4306/3=0,4769 ≅0,48

Ort(AVE)=7,8275/9=0,8697 ≅0,87

$GoF = \sqrt{(0{,}48) \times (0{,}87)}$ = **0,644**

Since *GoF*=0.644>0,36 the model has a very good fit.

- If the VAF value (mediation effect dimension) is below 20%, there is zero effect, if it is between 20%-80%, partial effect, and if it is above 80%, full effect is mentioned there (Çakır, 2020). The VAF calculation was made in the "Evaluation of the Mediation Effect" section.
- Another value that should be given when performing path analysis is the Q^2 value. If the Q^2 value is >0 for any endogenous (dependent) variable, it is inferred that the pathway model has an estimated significance level for that construct. SmartPLS calculates the 7-states Q^2 value. This value is not calculated for exogenous (independent) variables (Çakır, 2020). According to the current model, all Q^2 values of the dependent variables determined automatically by the program are given in Table 11 below.

Table 11
Q^2 values

Dependent Variable	**1.State**	**2.State**	**3. State**	**4. State**	**5. State**	**6. State**	**7. State**
EEASEOFUSE	0,2281	0,2044	0,1460	0,2261	0,2629	0,2922	0,0403
BINTENTION	0,0335	0,3818	0,4068	0,3803	0,3809	0,5128	0,3198
EUSEFULNESS	0,3532	0,3283	0,2917	0,2999	0,4449	0,4527	0,3491

If the Q^2 value is in the range of 0.02-0.14, it means that there is a small predictor among the factors, a medium predictor in the range of 0.15-0.34, and a large predictor if it is more than 0.35. It is seen from the table that most of the factors have medium and high predictive values.

- F^2 (Effect Size), in addition to evaluating the R^2 values of all endogenous (dependent) latent variables, determines whether an exogenous (independent) latent variable, is removed from the model, and whether this subtracted variable has a significant effect on the endogenous latent variables and it is used for evaluation purposes (Yılmaz and Kinaş, 2020). The effect size of a latent variable F^2 is weak if $0.02<F^2<0.14$, moderate if $0.15<F^2<0.34$ and high if $F^2>0.34$ at the structural level (Cohen, 1988). The F^2 values obtained as a result of the analysis are given in Table 12 below.

Table 12
F^2 values

	EEASEOFUSE	EENJOYMENT	OUTPUTQUALITY	EXTCONTROL	**BINTENTION**	EVACQINVOLV.	VOLUNT.	IMAGE	**EUSEFULNESS**
EEASEOFUSE	0,0000	0,0000	0,0000	0,0000	**0,4080**	0,0000	0,0000	0,0000	0,0000
EENJOYMENT	**0,1450**	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	**0,0431**
OUTPUTQUALITY	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	**0,6161**	**0,0128**
EXTCONTROL	**0,0929**	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
BINTENTION	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
EVACQINVOLV.	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	**0,2314**
VOLUNTARINESS	0,0000	0,0000	0,0000	0,0000	**0,0473**	0,0000	0,0000	0,0000	0,0000
IMAGE	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	**0,0324**
EUSEFULNESS	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000

There are only incoming arrows to latent variables of Behavioral Intention and Expected Usefulness, but no outgoing arrows according to the model.

On the other hand, Expected Ease of Use and Image factors appear as possible mediator variables according to the model.

Removing the Expected Ease of Use factor from the model has a high effect on the Behavioral Intention factor with a value of 0.4080. If the latent variable Expected Enjoyment is excluded from the model, it has an approximately moderate effect on Expected Ease of Use at 0.1450. If the Output Quality factor is removed, it has a high effect on the Image with 0.6161. If the External Control factor is removed from the model, the Expected Ease of Use factor has a weak effect with 0.0929. Subtraction of the Involvement in EV Acquisition factor has a moderate effect with 0.2314 on the Expected Usefulness factor, while subtracting the Voluntariness factor has a weak effect on the Behavioral Intention factor with 0.0473. It is seen in Table 12 that the image factor has a weak effect with 0.0324 on the Expected Usefulness factor.

If all these criteria are within the reference limits, path analysis can be started.

4.3 Evaluation of Structural Model (Path Analysis)

The H0 hypothesis was rejected when the p values were <0.05 in the established hypotheses and it indicates a significant difference between the factors. Acceptance of the alternative hypotheses H1, H2, H3, H4, H5, H6, H7, H8, H9, which reveal that the factors have a significant and positive effect on each other, will confirm the arrows between the factors seen in the model. Therefore, if H0 is accepted, the connecting arrow corresponding to the relevant hypothesis should be deleted from the model.

The p values of the hypotheses and the decisions taken as a result are given in Table 13 below.

Table 13
Results of hypotheses

Hyp.	Relationship	Path Coeff.	t Value	P Value	Alternative Hypothesis Decision
H1	IMAGE => EUSEFULNESS	0,1820	2,4634	0,0139	Accepted
H2	OUTPUTQUALITY=> IMAGE	0,6174	11,7053	0,0000	Accepted
H3	OUTPUTQUALITY => EUSEFULNESS	0,1086	1,4573	0,1453	Rejected
H4	EENJOYMENT => EUSEFULNESS	0,1815	2,9394	0,0034	Accepted
H5	EENJOYMENT => EEASEOFUSE	0,3461	5,0482	0,0000	Accepted
H6	EXTERNALCONTROL => EEASEOFUSE	0,2770	4,7880	0,0000	Accepted
H7	VOLUNTARINESS => BINTENTION	0,1820	3,0537	0,0023	Accepted
H8	EVACQINVOLVEMENT => EUSEFULNESS	0,4051	6,2151	0,0000	Accepted
H9	EEASEOFUSE => BINTENTION	0,5344	10,0783	0,0000	Accepted

As a result, only H3 out of 9 alternative hypotheses was rejected; because the p value is 0.1453 which is >0.05. In other words, it means that there is no relationship between Output Quality and Expected Usefulness. In this case, the linking arrow between Output Quality and Expected Usefulness must be deleted from the model.

4.4 Evaluation of the Mediation Effect

The mediation effect (VAF) is checked when there are relationship arrows going in and out of any factor at the same time. From this point of view, the mediation effect is seen only in the Expected Ease of Use and Image factors. In this case, these effects will be tested with new additional hypotheses.

The hypotheses with which the mediation effect was tested are as follows:

H0: It is the common hypothesis representing that there is no mediator effect in the relationship between the factors.

H10: Expected Ease of Use has a mediator effect on the relationship between Expected Enjoyment and Behavioral Intention.

H11: Expected Ease of Use has a mediator effect on the relationship between Perception of External Control and Behavioral Intention.

H12: Image has a mediator effect on the relationship between Output Quality and Expected Usefulness.

p values of the hypotheses established, and the decisions made are given in Table 14.

Table 14
Mediation effect evaluation

Hyp.	Relationship	Direct Effect	Total Effect	Indirect Effect	P Value	Decision
	EEASEOFUSE => BINTENTION	0,5344	0,5344			
	EENJOYMENT => EEASEOFUSE	0,3461	0,3461			
	EENJOYMENT => EUSEFULNESS	0,1815	0,1815			
	OUTPUTQUALITY => EUSEFULNESS	0,1086	0,2210			
	EXTERNALCONTROL => EEASEOFUSE	0,2770	0,2770			
	EVACQINVOLVEMENT => EUSEFULNESS	0,4051	0,4051			
	VOLUNTARINESS => BINTENTION	0,1820	0,1820			
	IMAGE => EUSEFULNESS	0,1820	0,1820			
	OUTPUTQUALITY => IMAGE	0,6174	0,6174			
H10	EENJOYMENT => BINTENTION			0,1850	0,0000	Accepted
H11	EXTERNALCONTROL => BINTENTION			0,1481	0,0001	Accepted
H12	OUTPUTQUALITY => EUSEFULNESS			0,1124	0,1551	Rejected

H10 and H11 hypotheses were accepted since $p<0.05$. That is, Expected Ease of Use has a mediator effect between Expected Enjoyment and Behavioral Intention. Likewise, Expected Ease of Use has a mediator effect between Perception of External Control and Behavioral Intention.

However, since $p=0.1551>0.05$ for the H12 hypothesis, the H0 hypothesis was accepted. In other words, Image does not have a mediator effect on the relationship between Output Quality and Expected Usefulness.

The mediator effect dimension of the "Expected Ease of Use" factor is calculated with the VAF value and VAF values are given in Table 15.

Table 15
VAF value calculation and decision table

Hyp.	Relationship	Path Coeff. (b)	Path Coeff. (c)	Total Indirect Effect (b*c)	P Value	Total Effect (b*c+a)	VAF (b*c) / (b*c+a)	Decision
H10	EENJOYMENT => EEASEOFUSE => BINTENTION	0,3461	0,5344	0,1849	0,0000	0,1850	0,999	Full effect
H11	EXTERNALCONTROL => EEASEOFUSE => BINTENTION	0,2770	0,5344	0,1480	0,0001	0,1481	0,999	Full effect

"b" is the path coefficient between the first and the second factor and "c" is the path coefficient between the second and the third factor. When these two coefficients are multiplied, the total indirect effect values are obtained. When calculating the VAF value;

$$VAF = b * c/(b * c + a) \tag{4.2}$$

equation was used (Nitzl and Hirsch, 2016). The "a=0,0001" value is the direct effect value between the two factors. In this case;

H10 VAF value: 0,1849/0,1850=0,999

H11 VAF value: 0,1480/0,1481=0,999 are calculated.

The VAF value is used to calculate the ratio of the indirect effect and the total effect (Çakır, 2020). If VAF values are < 20%, it means zero mediator effect; if between 20-80%, it means partial mediator effect and if > 80%, it means full mediator effect (Hair, Ringle and Sarstedt, 2013).

As a result, it was confirmed that Expected Ease of Use had a full mediator effect, i.e., Expected Enjoyment affects Expected Ease of Use, and Expected Ease of Use affects Behavioral Intention. Likewise, it was confirmed that Perception of External Control affects Expected Ease of Use and Expected Ease of Use affects Behavioral Intention.

The final electric car Technology Acceptance Model obtained for potential users in Türkiye is given in Figure 9 below.

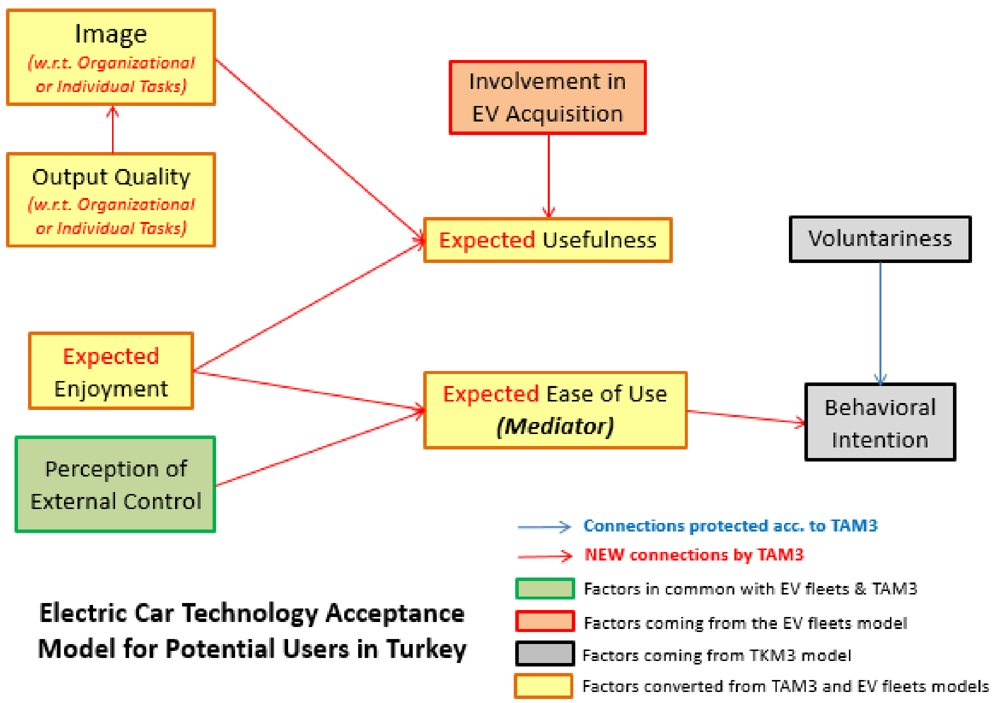

Figure 9 Electric Car Technology Acceptance Model for Potential Users in Türkiye

SmartPLS diagram of the final model is given in Figure 10 below.

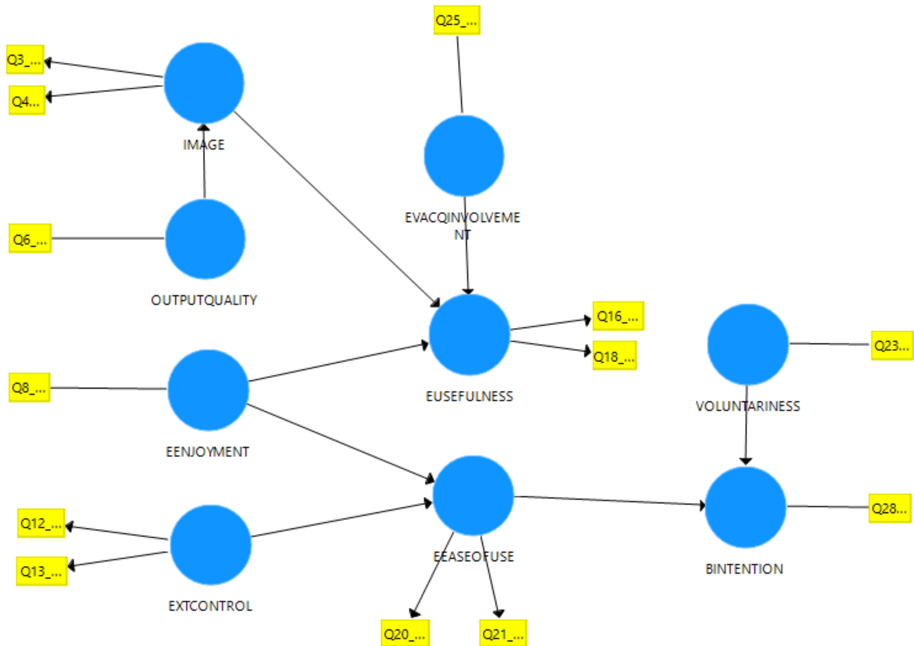

Figure 10 SmartPLS Model for Potential Users in Türkiye

5. Discussion and Conclusions

According to the Likert scale used in this study, the left skewed distribution means that there are positive responses to the questionnaire, which disrupts the normal distribution. For this reason, analyzes were continued with the PLS-SEM method via SmartPLS package program, which does not require normality condition.

Problems such as the requirement of at least two observable variables encountered in the AMOS program, and the extremely high chi-square value due to not having a normal distribution are not in question in the SmartPLS program.

On the other hand, if there is only one question under the factors, that is, there are univariate factors, some tabs in the AMOS program may be blocked.

In addition, although a maximum of 3 stages of modification is allowed during model improvement in the AMOS program, such a limitation was not encountered in the literature for SmartPLS. As a matter of fact, due to such advantages, the use of SmartPLS for any data which is not normally distributed, is increasing in the literature.

- A larger and more complex initial model, consisting of a total of 12 factors and 29 questions at the beginning, was reduced to a simpler model consisting of a total of 9 factors and 13 questions as a result of the PLS-SEM analysis. This situation resulted from the model's need to meet the fit criteria.
- Cronbach's alpha values were calculated in the range of 0.7430-1,000. It is interpreted that the models in the scale with a high Cronbach alpha coefficient consist of items that are measuring the same feature. Cronbach's alpha coefficient is frequently used in Likert-type scales (Yıldız and Uzunsakal, 2018), but when the literature is examined, there is criticism in case when the Cronbach coefficient is above 0.90. It has been suggested that the low coefficient calculated may be due to the low number of questions, whereas when the number of questions is high, the coefficient may be high, but when it is above 0.90, there may be unnecessary questions in the scale, and in this case, it has been suggested that some questions should be removed (Cortina, 1993; Tavakol and Dennick, 2011). For this reason, the fact that the coefficient gives a result above 0.90 does

not necessarily mean that it is reliable. Instead of making a decision with this coefficient alone, it should be interpreted with other reliability coefficients (Çakır, 2020).

- In this study, it was seen that majority of the Cronbach's alpha values were >0.90, as given in Table 7. For this reason, final decision on reliability was made by looking also at the other reliability coefficients such as rho_A, CR and AVE values. The rho_A coefficients were calculated in the range of 0.7439-1,000. The Rho_A coefficient is a better measure of reliability than Cronbach's alpha in Structural Equation Modeling. Although it is a coefficient that provides a better estimation of data consistency, the results obtained show whether the factor items are reliable or not and it is very important for SEM (Dijkstra and Henseler, 2015). A high coefficient of this confirmed the study in terms of reliability of the factors and data consistency.
- The HTMT criterion is important in terms of separating factors from each other. If a question gives an approximate value of 1 under another factor other than its own factor, it means that the factors are not differentiated, that is, they are perceived as the same factor. For example, if a question about the Image factor gives a value close to 1 and above 0.90 under the Output quality factor, it can be said that Image and Output Quality are perceived as the same factor. In this study, the HTMT criterion played an important role in the improvements made on the first proposed model. Improvements were made on removing the questions included under another factor from the model.
- There is no general fit index in PLM-SEM, and the GoF has been suggested as a measure of GoF (Tenenhaus, Vinzi, Chatelin and Lauro, 2004). In this study, the GoF index was calculated as 0.644, and GoF>0.36 indicates a very good fit. The GoF index was developed to determine the performance of both the measurement model and the structural model and to provide a standard measure for the predictive performance of the whole model. By calculating this value, it was concluded that the model had a very good fit.
- According to the VAF (mediation effect dimension) analyzes made for the Expected Ease of Use and Image factors to check the mediator position, it was understood that the Image was not a mediator, i.e., there is neither a direct nor an indirect relationship between Output Quality and Expected Usefulness. Nevertheless, Expected Ease of Use was identified as a mediating factor, as shown in the final model.
- When the Electric Car Technology Acceptance Model given in Figure 4.2 for Potential Users in Türkiye is examined;
    - Although the electric car technology enables the business or individual to perform certain tasks (Output Quality), it does not affect the performance of the organization or individual (Expected Usefulness).
    - Performing certain tasks for the organization or individual (Output Quality) by the use of electric car technology is related to the expectation that it will increase the social status of the person (Image). In other words, if the electric car performs certain tasks for the organization or individual, it can be interpreted that it will increase the reputation of the organization or individual as well.
    - An individual who thinks driving an electric car will be enjoyable (Expected Enjoyment) anticipates it will be easy to use (Expected Ease of Use) and therefore intends to own an electric car (Behavioral Intent). Likewise, an organization or individual who thinks that the service and technical infrastructure required to drive an electric car exists (Perception of External Control) for continuous support, predicts that electric car use will be easy (Expected Ease of Use). For this reason, the individual intends to own an electric car (Behavioral Intent).

- The idea that using an electric car will increase its positive image (Image) affects the expectation that it will increase the job performance (Expected Usefulness). In other words, if the electric car adds prestige to the person, performance can be positively affected by this.
- An organization or individual thinking that driving an electric car will be enjoyable (Expected Enjoyment) also expects it to increase the job performance (Expected Usefulness). In other words, it can be deduced that the performance of a person who enjoys driving an electric car will increase in daily work.
- Purchasing an electric car or supporting its acquisition in organizations (Involvement in EV Acquisition) affects the expectation that business performance will also improve (Expected Usefulness). In other words, individuals or organizations to buy electric cars will make this acquisition, hoping that their performance will increase in their daily work.
- The decision to accept an electric car without any obligation (Voluntariness) affects one's intention to drive an electric car (Behavioral Intention). In other words, if someone is not necessarily interested in and accepts use of electric cars, it can be said that this person also intends to buy an electric car, which is related to the use of technology.

After mass production start of Türkiye's domestic electric car brand (TOGG) by the end of 2022 as planned, and with also new market entrances of other electric vehicle brands, this study should be repeated again. This will then enable us to measure the electric car perception and technology acceptance level of all direct users in Türkiye.

In this way, it will be possible to compare between how electric car technology was perceived when it was not widespread and in case after it is widely used in Türkiye. However, in the second comparison study, which will be held probably a few years later, the participants will need to be selected from a wider range of only direct electric car users. In this case, some changes can naturally be expected in the relationships and also the final model, depending on the new survey data as the user composition changes.

As the last word it can easily be said that the methodology followed in this study can potentially be used in all kinds of Perception and Technology Acceptance Modeling studies in other fields whose data do not comply with the normal distribution.

Research and publication ethics were complied with in this study.

Contribution of Researchers

In this research, Üzeyir PALA contributed in determining the research topic, analyzing, controlling, and revealing the program outputs, examining the results, writing the article, and Muazzez MOLA contributed to the issues of literature research, creating the mathematical model in the computer environment, researching the methods to be used in the solution and applying it to the problem to obtain the results.

Conflict of Interest

No conflict of interest has been declared by the authors.

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