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Research Article

Examination of Cyber-Physical System Applications in Manufacturing Enterprises with the Unified Technology Acceptance and Utilization Theory

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Keywords

Cyber Physical System (CPS), Unified Technology Acceptance and Utilization Theory (UTAUT), Performance Expectancy, Social Influence, Effort Expectancy, Facilitating Conditions, Use, Behavioral Intention.

Abstract

In this study, the perception, acceptance and usage status of Cyber Physical Systems (CPSs) which seem likely to become a more dominant tool in the industrial sector in the coming years, in manufacturing industry enterprises, and the advantages it provides to small and medium-sized enterprises (SMEs) in the manufacturing sector are examined in line with the requirements of the sector. In this regard, the study will offer comprehensive insights to researchers, scientists, and decision-makers within industrial sectors, as well as institutions and organizations tasked with making strategic decisions. In addition, as with any new technology, the importance of determining the attitudes of staff and managers, who are the users of the technology, towards CPS was evaluated with an acceptance model developed by considering industrial conditions. By applying a questionnaire with open-ended questions including the opinions of SMEs, it is aimed to examine the factors in the Unified Technology Acceptance and Utilization Theory (UTAUT) model whose effects on usage are advocated. analysis demonstrate that the major hesitations of the enterprises are concentrated on the high costs of the technology, the lack of human resource competence to use the systems and the lack of solution partners in case of possible failures, but they still have positive opinion about the use. The study's findings shed light on the factors influencing the feasibility of CPS technology in the industrial sector. These results can serve as a guide for conceptualization, policy support, planning, and the development of new management strategies that will be essential in this field in the forthcoming years.

1. Introduction

Today, technological developments and digitalization require businesses to make their decision-making processes faster in order to maintain their existence with change. In this direction, especially manufacturing industry enterprises benefit from information technologies more and more every day in order to adapt their production processes to competitive conditions, to keep product costs under control and to stay competitive on global scale. In order to compete in the global market, where it is getting more difficult to exist every day, or to achieve competitive advantage and to adapt to digital transformation, enterprises seek to access new information technologies that create cost efficiency and offer advantages to business processes.

In the past, the technology strategy of businesses was based on purchasing large amounts of software and hardware to get a competitive advantage through economies of scale. However, in today's changing and evolving business world, such strategies are no longer sufficient to meet business demands. Organizations need to access all their requirements in a smart, fast, flexible, high quality and cost-effective manner in a globally competitive environment; therefore, investments in smart technologies that integrate information technologies and the physical ecosystem of machines increase productivity and provide competitive advantage. These systems, called Cyber Physical Manufacturing Systems, started to be used in developed countries in the 2000s and started to be widely used in our country in the 2020s. Until the 2000s, the globalization of the market beyond its regional and national borders with the effect of globalization brought even the simplest manufacturing enterprises to face global competitors with great technological power in the market. In such a market structure, strategies such as quality-based competition/price-based competition began to give a chance to market actors who could offer both price and quality at the same time by integrating with each other. Smart production systems have enabled both the production of products with minimal errors with the optimal effect of technology and the highest amount of production per unit time with the available technology. The digital world called Industry 4.0 has become the basic premise of all countries in development, such as minimizing the need for labor force in production processes, the interaction of machines with each other via the internet, and the possibility of enterprises to access the most comprehensive analysis and information sources (big data) related to their own production, supply management and markets.

Global competition for the integration of digital technologies with huge budgets in almost all sectors from defense industry to energy sector, from medicine to electronics has also developed corporate adaptation or corporate resistance mechanisms against digital culture in enterprises. While businesses that have institutionally adapted to the process have encountered negative entropy with digital technologies, institutional resistance has sometimes led to the entropy of digitalization in businesses.

In the process where CPSs are becoming more and more widespread in manufacturing industry enterprises, it is of particular importance to measure the ability of employees and managers to adopt, assimilate and adapt to these systems and to determine the level of adaptability to this new production culture. It is of particular importance to determine the situation in order to obtain the expected efficiency from smart production systems and to develop policies for the

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adaptation of the corporate resources of enterprises to the smart CPS culture.

CPS in which physical mechanisms are controlled or monitored by computer-based algorithms, constitute the main infrastructure of smart manufacturing. In fact, the ultimate goal of CPS is to realize full automation of production processes in the most secure and efficient way. In addition, CPSs also provide significant advantages in manufacturing, such as scalability, reliability, high performance and definable configurability.

One of the most important pillars of CPS technology is Cyber Physical manufacturing systems. These systems, which the industrial sector all over the world sees as a new way of superior competition, have started to shape the industrial policies of governments. One of the biggest difficulties encountered in our country in the integration of cyber physical manufacturing systems into the industrial sector is the risk that the level of acceptance of this technology by managers and employees, especially in labor-intensive sectors, may remain low due to their cultural commitment to traditional production methods. However, it is also a fact that there is no academic study on the subject in our country.

The necessity of intensive usage of CPS and information technologies in the manufacturing industry sector, which is one of the technology-oriented sectors, will direct business managers to disseminate information systems and CPS technologies suitable for the organizational structures and business areas of the enterprises operating in the sector. However, the failure to take into account the level of acceptance and adoption of these technologies by the end-users and decision-makers who will use information systems and technologies will negatively affect the success that these technologies will provide to businesses. Therefore, the focus of this paper is to investigate how much CPS users in manufacturing enterprises accept and adopt the systems they use. It is a fact that research on CPS technologies has not sufficiently studied user acceptance and satisfaction. The survey study includes the feelings, tendencies, intentions and behaviors of current CPS users in manufacturing enterprises towards using the system. The scarcity of sectoral studies on technology acceptance and the absence of previous research on the utilization of CPS technology and information systems specific to the manufacturing sector increase the importance of this study.

The present study aims to investigate the process of acceptance and diffusion of the idea of change and development, which is at the focal point of industrial policies, by individuals representing enterprises (managers-authorities) within the framework of CPS technologies, the last link of technological transformation. The theoretical model is compared with the practical application and the statistical results are verified by testing the model in a real structure. CPSs are considered as the underlying technology and within this framework, two main objectives are pursued in the research: Firstly, statistically determining the factors that business owners are influenced by when implementing CPS technology with the UTAUT, and secondly, examining the CPS structure in manufacturing industry enterprises and evaluating the structural results obtained together with the statistical results. In this context, the general objective is to make determinations that will contribute to the road map to be drawn by our country on digital technological transformation, which is the main parameter of industrial development in today's world., Although many models of technology adoption and acceptance have been used in the literature, the UTAUT model, which is one of the most recently developed models and is a powerful model that cross-integrates the elements of eight models was chosen in the present study. In this context, the validity of the UTAUT model was assessed within the manufacturing sector in Turkey. Moreover, the study seeks to elucidate the validity of factors influencing individual acceptance of the current CPS by users within surveyed enterprises, shedding light on any anomalies related to the adoption of CPS, which is relatively novel in our country.

2. Literature

2.1. Technology Acceptance Models

In the 1980s, researchers started their research by focusing on the factors of organizations' use of information systems and the adoption and use of information technologies [1]. IT specialists working on information technologies initially used intention models from social psychology in their research. Social psychologists have investigated how and why individuals prefer to change an action in order to explain the attitudes that affect individual action in these models. With Charles Darwin's definition of attitude as the psychological pressure of an emotion in 1872, research on attitudes influencing action began more than 150 years ago. Social psychologists state that attitude includes behavior and knowing and that there is a positive relationship between these two factors. Several theories have been used in information systems studies to explain the technology adoption process at both the individual and organizational level [2]. These theories include UTAUT [3], Technology Acceptance Model (TAM)[4] and Technological Organizational Environment Model (TOE)[5]. While TOE and DOI analyze at the organizational level, UTAUT, TAM and TPB are theories that consider individuals as the analysis factor [2]. In recent years, research on technology adoption has developed significantly and the main reason for this progress is the increasing dependence of people on technology. The TAM, Theory of Reasoned Action, Theory of Planned Behavior, and UTAUT and Use are among the most cited theories in the field of technology adoption [6].

2.2. UTAUT

UTAUT is one of the most recent technology use models. It was developed as a result of a review and synthesis of eight technology use theories or models [7].

UTAUT has various contributions to the literature on TAMs. The model provides empirical insight into technology acceptance compared to other technology acceptance theories. Research has shown that the UTAUT explains 70 percent of the variance of the proposed variables on intention to use and offers stronger predictive power than other theories examining technology acceptance [8]. UTAUT has demonstrated notable success in elucidating the variance in behavioral intention to use technology and actual technology use within organizational contexts. [9]. Therefore, in a field study on the adoption and use of CPS in enterprises, which are predominantly composed of enterprises with a strong corporate identity, UTAUT is considered to be an ambitious research method.

The fact that the number of TAMs are increasing day by day and that they have a similar structure has led to the inability to benefit from the advantages provided by other models if a single model is used. This situation has led researchers to combine existing models [10, 11, 12]. In 2003, Venkatesh and other researchers evaluated the factors and models in the TAMs and determined the appropriate factors among eight models and created the UTAUT [13]. These models are The Theory of Planned Behavior, The TAM, The Theory of Reasoned Action, The Social Cognitive Theory, The Innovation Diffusion Theory, The Motivational Model and The Model of PC Utilization. UTAUT aims to explain the behavior of users by successfully and effectively combining the variables in the above models [14].

The UTAUT model has been used to describe the technology adoption behavior of users. In this context, this model can effectively explain and analyze the technology acceptance behavior of enterprises for CPS technologies. Venkatesh and colleagues (2003) examined eight different theoretical models to identify the factors that influence people's adoption and use of technology and developed a unified model by combining these models. This model, called the UTAUT, shown in Figure 1, measures acceptance of technology, behavioral intention to use technology and actual usage behavior. Behavioral intention refers to individuals' willingness to use technology, while usage behavior represents the actual use of technology. According to the UTAUT model, performance expectancy, effort expectancy, and social influence are direct determinants of behavioral intention. Furthermore, the model posits that behavioral intention and

facilitating conditions are determinants of usage behavior. It is hypothesized that gender, age, experience, and volunteering factors mediate the impact of these four primary determinants on both behavioral intention and usage behavior. [3].

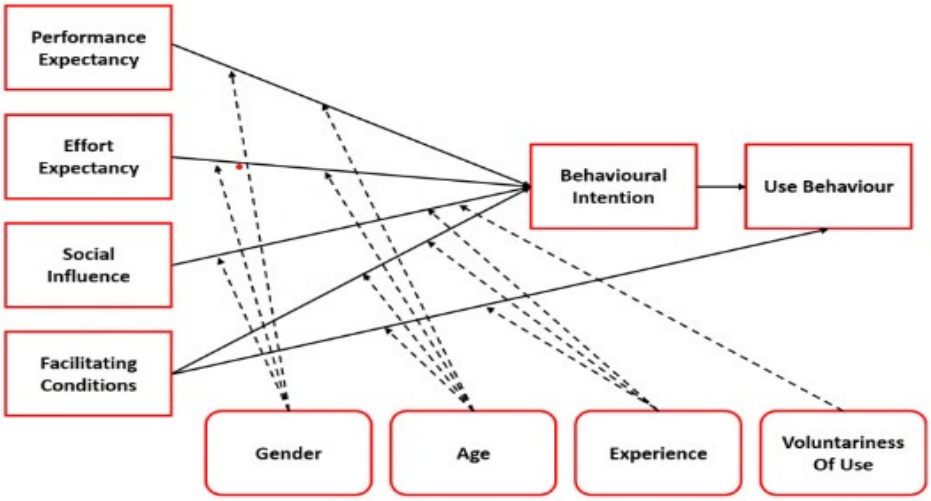

Figure 1. UTAUT model [3]

Technology adoption, as articulated in TAMs, is also critical to the fullfilment of supply chains' organizational strategies to improve CPS delivery and customer experience.

The present study aimed to investigate the use and adoption of CPS in primarily manufacturing industry and IT sector enterprises located in Sakarya province. Sakarya Province is a city where traditional and modern industry are intertwined and has the quality of being a capillary for both Istanbul and Ankara with the number of OIZs and factories increasing day by day.

With the field research conducted in this direction, the results that can be a role model for our country's manufacturing industry enterprises on determining the effects of the current state of use of CPSs for the next 10 years in the Turkish industry are aimed.

3. Research Model and Hypothesis

3.1. Research Model

According to the UTAUT model, there are determinants that directly affect the intention to use a new technology. These factors include performance expectancy, social influence, effort expectancy and facilitating conditions. These factors are important determinants that directly affect an individual's tendency to accept and use technology [3]. In this study, the use of CPSs in manufacturing activities based on the determinants of UTAUT is investigated through the behavioral intention of firms in Sakarya toward acceptance and use.

According to the UTAUT model, the hypothesis group is formed as shown in Figure 2.

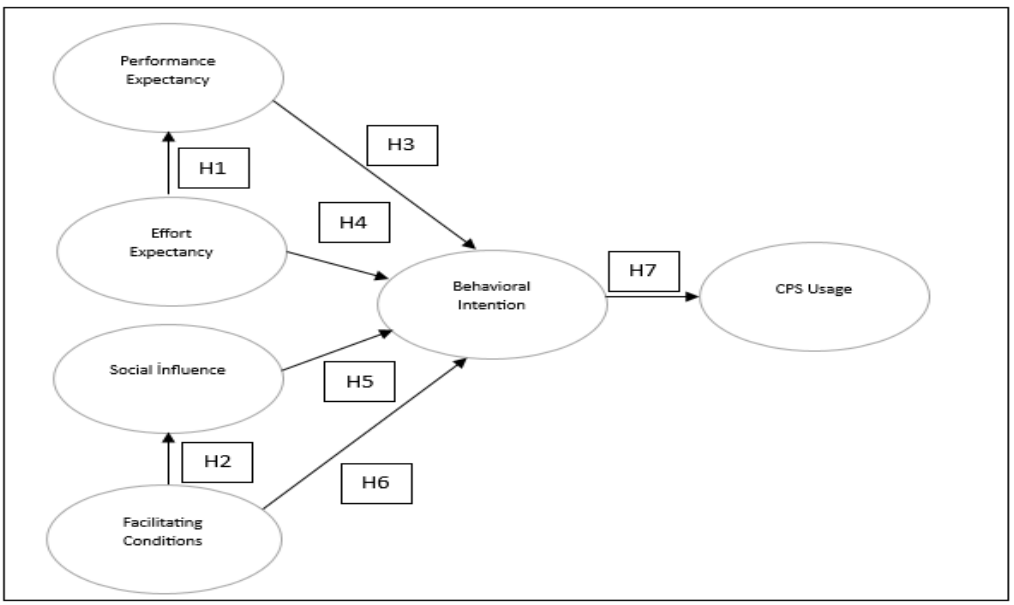

Figure 2. Research Model

3.2. Research Hypothesis

- Effort Expectancy:

Effort expectancy is defined as "the degree of ease of use of the system" [3]. A user perceives a system as easy to use if he or she thinks that it is functional and does not require much mental effort or effort to learn [15]. The perception that the application is easier to use encourages users to enjoy using the system, thus making it perceived as user-friendly [16]. In such a case, of course, it increases the perceived utility of the user.

- Performance Expectancy:

Previous studies have examined whether information technology investments positively affect business performance and the results have shown that these investments positively affect organizational performance [17]. In another study conducted on this subject, it was concluded that information technology investments affect business performance to a great extent [18].

Just like information technologies, CPS technologies, which are the projection of information technologies today, are vital for the success of businesses. Because quality products depend on the quality of technology as well as qualified human resources. For this reason, businesses sometimes invest in new technologies in order to make the right decisions, even if it is costly, but sometimes they do not achieve the desired performance [19]. Therefore, investigating the determinants that affect the utilization of CPS is critical for businesses and business employees. Successful integration of technologies can improve the performance of businesses, while unsuccessful implementation can lead to unintended consequences, financial losses and employee dissatisfaction.

In line with the views expressed in the literature, effort expectancy is expected to positively affect performance expectancy. Accordingly, hypothesis 1 is proposed as follows.

H1: Effort expectancy has a positive effect on performance expectancy in the adoption of CPS by users.

- Facilitating Conditions:

Facilitating conditions refer to the perceived level of adequacy an individual holds regarding an organization or its technical infrastructure to support the effective use of a system. Facilitating conditions were created from the factors of compliance and perceived behavioral control taken from TPB, CTAMTPB, MPCU and IDT models. Facilitating conditions have a direct positive effect on intention to use, but this effect starts to decrease relatively after the first use. For this reason, the model suggests that facilitating conditions have a direct positive effect on a person's use [3].

The positive effects of age, gender, experience and willingness to use define the influence of factors on intention to use. Age moderates the influence of other factors. Gender affects how performance expectancy, effort expectancy, and social influence relate to each other, while experience plays a moderating role in the strength of the relationships between social influence, effort expectancy, and facilitating conditions. Voluntary use only has a moderating effect on the link between social influence and behavioral intention [3].

Facilitating conditions refer to the conditions of understanding the technical features of the system such as the presence of user manuals and menus, online support. The facilitating conditions factor was included in the scope of the research in order to determine the factors that facilitate the use of CPS by enterprises and to determine whether their current situation is suitable for this technology.

- Social Influence:

Social influence refers to the personal norms, social variables and image constructs used in models such as TRA, TAM2, TPB, CTAMTPB, MPCU, IDT, etc., which show that people adjust their behavior according to others' perceptions of them. Social influence is very important when technology use is mandatory [3]. People may use technology not only when they want to, but also when they feel obliged [20]. This may explain why social influence is inconsistent in research [21,22]. As an example, preferences that stem from social influence rather than personal motives to create a social image, such as using a color that one does not like because it is trendy, or using a higher model phone to create an image in society even though one does not need it, can be shown. In the UTAUT, it is assumed that perceived benefit is influenced by two groups of variables called social influence and cognitive aids. The group measuring social influence includes voluntariness, subjective norms and image variables. Job fit, result demonstrability, output quality and perceived ease of use are the second group of variables defined as cognitive aids [20].

When businesses perceive that they have self-efficacy for the use of CPSs and that there are facilitating conditions for the use of the system, as well as when they feel social influence from their own ecosystems; it can be evaluated that the perceived ease of use, perceived benefit and intentions to use the system will be positively affected by CPSs [23]. Hypothesis 2 formed in this direction is as follows.

H2: Facilitating conditions in the adoption of the CPS by users have a positive impact on social influence.

- Performance Expectancy:

UTAUT posits that performance expectancy, social influence, and effort expectancy directly influence usage intention, and facilitating conditions and intention directly impact usage behavior. Additionally, it suggests that gender, age, experience, and volunteering moderate these relationships. Performance expectancy, defined as "the level to which a person believes that using the system will help him or her achieve positive gains in job performance," is a key determinant in various models including TAM, Combined TAM, TAM2, Theory of Planned Behavior, Motivational Model, and PC model constructs. Examining the factors affecting the acceptance of CPS is as important for business owners and employees as it is for businesses. While the effective and successful implementation of new technologies integrated into production and managerial processes improves the performance of businesses, unsuccessful implementation examples unfortunately bring undesirable results, financial bottlenecks or employee dissatisfaction.

- Behavioral Intention:

Behavioral Intention refers to the underlying motivations that drive the performance of a behavior. Put simply, the stronger the desire or motivation to engage in a behavior, the more likely it is that the behavior will occur. UTAUT has proven effective in elucidating the factors influencing behavioral intention toward technology adoption and usage, particularly within organizational settings. [24].

The UTAUT model has been extensively employed to characterize users' behavior in adopting technology. According to this theoretical framework, actual technology usage is contingent upon behavioral intention. The perceived likelihood of technology adoption is directly influenced by four primary factors: performance expectancy, social influence, effort expectancy, and behavioral intention. Moreover, the impact of these predictors is moderated by gender, age, experience, and willingness to use. Given that the fundamental tenet of the model asserts that actual technology usage hinges on behavioral intention, Hypothesis 3 of the research is formulated as follows:.

H3: Performance expectancy has a positive effect on behavioral intention in the adoption of CPS by users.

In line with the definitions made above, since it is foreseen that the expectation of effort will increase the behavioral intention in the adoption of the system by the users, the 4th Hypothesis of the research was formed as follows.

H4: Effort expectancy has a positive effect on behavioral intention in the adoption of CPS by users.

In line with the concepts of social influence and behavioral intention defined in detail above, it can be evaluated that when users perceive that they have self-efficacy for the use of CPSs and that there are

facilitating conditions for the use of the system, as well as when they perceive social influence from their environment, the perceived benefit from CPSs, perceived ease of use and intentions to use the system are also positively affected. The 5th Hypothesis formed in this direction is as follows.

H5: Social influence has a positive effect on behavioral intention in the adoption of CPS by users,

Facilitating conditions have a direct positive effect on intention to use, but this effect starts to decrease relatively after the first use. Since there is no previous study on the subject and it is not known whether the sample is first or experienced in the use of CPS, in line with the above assumption, Hypothesis 6 below was formed by suggesting that facilitating conditions have a direct positive effect on the person's use.

H6: Facilitating conditions in the adoption of CPS by users have a positive impact on behavioral intention.

As outlined above, according to the theoretical framework of UTAUT, the actual adoption and usage of technology are influenced by behavioral intention. Hypothesis 7 below is included in the research as it is assumed that there is a positive effect between businesses' CPS usage and frequency of use and intention to use it in the future.

H7: Behavioral intention in the adoption of CPS by users has a positive impact on CPS usage.

3.3. Method of the Research:

3.3.1. Population and Sample of the Study

The population is the set of items, entities or objects included in the research. All existing populations on which research can be conducted are within the scope of the population. A sample is a group of people, objects or items within the population.

According to the KOSGEB database, there are around 1400 enterprises with manufacturing and medium high technology NACE codes in Sakarya Province. Within this universe, there are around 450 enterprises with digitalization potential according to KOSGEB database. All of these enterprises were contacted by telephone method and 417 enterprises were contacted, except for 33 enterprises whose telephone information was outdated or could not be reached. Among these enterprises, appointments were made with 304 enterprises that already use or intend to use CPSs. The fact that Sakarya province is one of the most important industrial bases of the country, even just the number of samples that use or intend to use CPSs was enough to meet the 5% error margin of the confidence interval. A face-to-face survey was conducted with 282 enterprises due to reasons such as the company forgetting on the appointment day or the manager being absent. Four surveys were not included in the study due to errors and omissions. In this way, 278 surveys were included in the research.

In this context, 278 of around 450 enterprises with digitalization potential in Sakarya were included in the study. While determining the sample, convenience sampling method was used. Accordingly, with a 95% confidence interval and e=5% margin of error, the sample size of a universe of 450 people should be around 125 [25]. Since the population of the research is 450, the research study is within the 95% confidence interval.

3.3.2. Data Collection Method and Tool

Questionnaire method was used in the data collection phase of the research. In the research, it is aimed to collect data through a questionnaire to reveal the usability of CPS in the industrial field, the concerns and expectations of enterprises, and the factors affecting its use. The target group of participants determined to obtain data: business owners and business officials who have been or are in the position of white-collar managers.

The questionnaire consists of two parts:

- The first part explores the title, financial data, number of employees, sector, scale, activity code, technology level, gender and role of the respondent, characteristics of the participating enterprises; gender, age, education level, whether they use CPS or not.
- The second part includes the questionnaire statements presented in the Appendix. The questionnaire statements were adapted based on the questions whose validity and reliability were tested in the studies of Davis [26], Wu and Wang [27], Chunxiang [28] and Weng et al. [29]. In addition, a mixed questionnaire study was created by examining the field surveys previously conducted in similar fields in our country. The survey models utilized are presented below.

• Usability of The Internet of Things (IoT) In the Military Field and Acceptance Model Proposal [30]

• Determining The Use and Applicability of Cloud Computing on The Basis of Accounting Information System in Small and Medium Size Businesses in Turkey with Technology Acceptance Model Approach [31]

• Examination of The Factors Affecting the Use of Big Data and Analytical Systems with The Extended Technology Acceptance Model [32]

• Determining the Applicability of Cloud Computing Technology in Universities in Turkey with A Technology Acceptance Model Approach [33]

• The Investigation of the User Adoption of the Course Information System by Users with UTAUT Model [24].

Since there is no previous study to examine the use of CPSs in our country with any TAM, the questionnaire study was prepared in a unique way with the adaptation method.

3.3.3. Measurement Instrument of the Research

In the first part of the questionnaire used in the research, introductory information about the enterprise and the participant are questions to determine the information of the enterprises participating in the research. With the 20 questions in the continuation of the questionnaire, it was tried to determine how much the use of CPS was adopted by the enterprises. These 20 questions were prepared according to the Performance Expectation (PE), Effort Expectation (EE), Social Impact (SE), Facilitating Conditions (FC) and Behavioral Intention (BI) scales in the UTAUT model. These determinants in the UTAUT model directly affect usage behavior. In addition, demographic characteristics such as age and gender are known to stretch these relationships.

The data obtained through the survey were analyzed with the UTAUT model. In the UTAUT model; performance expectancy, effort expectancy, social influence, facilitating conditions, behavior intention and usage variables that are thought to affect user behavior are included in the model. In addition to these direct influencing variables, indirect influencing factors such as age, gender and experience are also examined. AMOS application was used to determine the link between these variables in the study and to conduct Confirmatory Factor Analysis (CFA) and Structural Equation Model Analysis (SEM). Structural Equation Modeling (SEM) is a powerful technique increasingly used in scientific research and is an effective method for testing and evaluating multivariate causal relationships.

3.3.4. Data Analysis

In the analysis of the data collected from the enterprises with the questionnaire, it was first determined whether the variable distributions were normal by applying the normality test. Then, the multicollinearity test was applied to examine whether there is a linear relationship between the variables [34]. In the validity and reliability analysis of the research scale, fit indices were used in line with the structural equation model. By looking at the value ranges of the results, it was checked whether the scale was valid and reliable. With CFA, the size of the sample and the compatibility of the variables were analyzed. The method used in verifying the hypotheses of the research model and determining the relationship between the factors was utilized to reveal meaningful findings [35]. Finally, Structural Equation Modeling was used to examine the compatibility of the research model with the data collected through the questionnaire. Goodness of fit measurements should be within the expected value range. A high goodness of fit value indicates that the relationship

between the variables is strong, while a low value indicates that the model is not appropriate. AMOS program was used to determine the connection between the variables in the study and to conduct Confirmatory Factor Analysis (CFA) and Structural Equation Model Analysis (SEM). SPSS application was also used for frequency analysis. The goodness of fit indices and values used in the model are as follows:

Chi-Square Test (Chi-Square Index -CMIN): The χ2 test assesses the hypothesis when there's a disparity between the covariance matrix anticipated by the model and the actual covariance matrix. Hence, it's favorable to have a non-significant discrepancy. In Structural Equation Modeling (SEM), for the best fit, the χ2 test is considered ideal when p > 0.05, indicating that the model's anticipated covariance matrix aligns well with the observed covariance matrix [36, 37, 38].

Root Mean Square Error of Approximation (RMSEA): RMSEA serves as an indicator of model fit quality, where a value of 0 represents a perfect fit, while higher values suggest poorer fit. It's particularly effective in detecting model misspecification and is less influenced by sample size compared to the χ2 test. For a model to be considered acceptable, RMSEA should ideally be less than 0.06. [39,38,40].

Goodness-of-Fit Index (GFI): The GFI typically ranges from 0 to 1. A value of 1.0 indicates a perfect fit, although achieving this value is rare in practice. However, GFI is no longer recommended as a primary fit index because it can be influenced by sample size [41, 42].

Adjusted Goodness-of-Fit Index (AGFI): AGFI is a modification of GFI that accounts for the degrees of freedom in a more saturated model. AGFI tends to increase with sample size. Similar to GFI, AGFI values range from 0 to 1, with values of 0.90 or greater generally considered to indicate good fit in models. However, it's important to note that AGFI, like GFI, has limitations and should be interpreted alongside other fit indices for a comprehensive assessment of model fit.

Comparative Fit Index (CFI): CFI represents the amount of variance explained in a covariance matrix. Its values range between 0.0 and 1.0. A higher CFI value indicates a better model fit. In practice, CFI should be close to or higher than 0.95 [38].

Normed Fit Index (NFI): NFI is highly sensitive to sample size. Therefore, NFI is no longer used to assess model fit [36].

Non-Normed Fit Index (NNNFI): An incremental measure of goodness of fit for a statistical model that takes into account the size of correlations in the data and the number of parameters in the model. This index provides an adjustment to the Normative Fit Index, which includes the degrees of freedom in the model [44].

Standardized Root Mean Square Residual (SRMR): SRMR is similar to RMSEA and its value should be less than 0.09 for a good model fit [38]. Since the RMR can be difficult to interpret, it is easier to use the SRMR.

Relative Fit Index (RFI): Relative fit index, also known as RHO1. It is not guaranteed that the values it can take will vary between 0 and 1. However, RFI close to 1 shows a good fit [24].

Composite reliability (CR) was calculated to assess the internal consistency of the measurement model. As seen in the Table 2, the CR values of the scales included in the model are above the critical value. This proves that all of the scales have strong and sufficient reliability and discriminate validity. In addition, the average variance extracted (AVE) values between 0.61 and 0.74 were obtained and these values are above 0.5 [45].

Table 1. Goodness of Fit Indices [38]

Goodness of Fit Indices	Ideal Fit Criteria	Acceptable Fit Criteria
CMIN	P>0.05 is requested.	-
CMIN/DF	0≤ CMIN/DF≤2	2≤ CMIN/DF≤5
RMSEA	0≤ RMSEA ≤0,05	0,05≤ RMSEA ≤0,10
GFI	0,95≤ GFI ≤1	0,90≤ GFI ≤0,95
AGFI	0,90≤ AGFI ≤1	0,80≤ AGFI ≤0,90
CFI	0,95≤ CFI ≤1	0,90≤ CFI ≤0,95
NFI	0,95≤ NFI ≤1	0,90≤ NFI ≤0,95
TLI	0,95≤ TLI ≤1	0,90≤ TLI ≤0,95
SRMR	0≤ SRMR ≤0,05	0,05≤ SRMR ≤0,10
RFI	0,90≤ RFI ≤1	0,85≤ RFI ≤0,90

Normality Tests: The mean, standard deviation and normality distributions of all factors in the study are analyzed below.

Table 2. Standard Effect and Normality Distribution

FACTORS	AVE	CR	STANDARDIZED EFFECT
PE	0,72	0,80	0,70
PE1			0,90
PE2			0,69
PE3			0,49
PE4			0,73
EE	0,85	0,82	0,74
EE1			76
EE2			84
EE3			77
EE4			62
SN	0,74	0,79	0,74
SN1			71
SN2			83
SN3			68
FC	0,64	0,68	0,64
FC1			56
FC2			71
FC3			65
BI	0,81	0,71	0,67
BI1			82
BI2			68
BI3			52
USE	0,57	0,58	0,61
USE1			51
USE2			55
USE3			77

The standard deviations of the hypotheses determined within the scope of the research are presented in the Table 3 below.

Table 3. Standard Deviations of Hypotheses

Hypothesis No	Hypothesis Definition		Standard Load	Standard Error	Critical Ratio
H1	PE<---	EE	,450	,073	6,159
H2	SN<---	FC	,652	,106	6,150
H3	BI<---	PE	,652	,106	6,150
H4	BI<---	EE	,112	,081	1,389
H5	BI<---	SN	,168	,064	2,642
H6	BI<---	FC	,141	,081	1,743
H7	USE<---	BI	1,175	,151	7,760

When Table 3 is examined, it is determined that the factor with the highest mean is performance expectation and social impact, while the factor with the lowest mean is utilization. When the standard errors of the hypotheses are analyzed, it is determined that the hypothesis with the lowest critical ratio is hypothesis 4 and the hypothesis with the highest critical ratio is hypothesis 7. Normality test was conducted to determine whether the data belonging to performance expectancy, effort expectancy, social influence and behavioral intention factors are normally distributed. Goodness of fit values and acceptable values obtained through the analysis are presented in Table 4.

Table 4. Goodness of Fit and Acceptable Values

Compliance Indices	Confirmatory Factor Analysis (CFA) Fit Index Values	Limits of Good Fit of Indices	Limits of Acceptable Concordance of Indices
CMIN (χ^2)	321,956		
Degrees of Freedom (df)	155		
P	0,000		
CMIN/DF (χ^2/df)	2,077	χ^2/df≤3	χ^2/df≤5
RMR	0,010	RMR ≤ ,05	RMR ≤,08
GFI	0,892	,90 ≤ GFI	,85 ≤ GFI
AGFI	0,853	,90 ≤ AGFI	,85 ≤ AGFI
CFI	0,926	,97 ≤ CFI	,95 ≤ CFI
RMSEA	0,062	RMSEA ≤ ,05	RMSEA ≤ ,08

According to the Table 4, the CMIN/DF (✓2/df) value is 2,077. CMIN/df (CMIN divided by degrees of freedom) is usually used to interpret the CMIN value. The smaller the CMIN/df value, the stronger the evidence that the model fits the observed data well. The "limit of good fit" of the CMIN value is not a precise value and depends on many factors, such as the complexity of the model, the size of the sample, and the values of other goodness-of-fit indices. However, generally, a CMIN/df value between 2 and 5 indicates a good fit. A value in this range indicates that the model provides a good fit to the observed data.

In the Table 4, the RMR value is 0.010. The RMR is the root mean square error of the difference between the model predicted and actual data. A lower RMR value indicates a better fit of the model to the observed data. The RMR value is below the limit of good fit and acceptable fit.

Based on Table 4, the GFI value is reported as 0.892. GFI values range between 0 and 1, where higher values indicate a stronger fit between the model and observed data. Generally, a GFI value exceeding 0.90 suggests an acceptable fit, although some researchers advocate for a higher threshold, such as 0.95. It's crucial to evaluate the GFI alongside other goodness-of-fit indices like CFI, RMSEA, and SRMR for a more comprehensive assessment of model fit. In summary, GFI serves as an indicator of how well a structural equation model aligns with observed data, with higher values indicating stronger evidence for a good model fit. According to Table 4, the AGFI value is reported as 0.853. Adjusted Goodness of Fit Index, is calculated considering the degrees of freedom of the model and the sample size, making it a corrected version of GFI. Similar to GFI, AGFI values range between 0 and 1, where higher values indicate stronger evidence of model fit.

Additionally, Table 4 indicates that the CFI value is 0.926. CFI, or Comparative Fit Index, also ranges between 0 and 1. A CFI value closer to 1 suggests a better fit between the model and observed data. Generally, when the CFI value exceeds 0.90, the model is deemed to offer an acceptable fit.

The RMSEA value is the most important value in the Table 4 and the basic value of the acceptability of the model. According to the analysis, the RMSEA value is 0.062. The RMSEA value is used to measure how well the model fits the observed data. The RMSEA value takes a value between 0 and ∞ (infinity). The lower the RMSEA value, the stronger the evidence that the model fits the observed data. Generally, when the RMSEA value is between 0.05 and 0.08, the model is considered to provide an acceptable fit. However, some researchers suggest a lower threshold value of 0.06.

When the goodness of fit indices in the Table 4 are evaluated together, it is seen that the model created according to the analysis results has an acceptable fit4.

4. Research Findings

In this section of the study, tables and interpretations of the findings of the analysis of the survey data obtained from the participants are presented.

4.1. Findings on Participant Information

The classification of the enterprises participating in the research according to the NACE "European Statistical Classification of Economic Activities" code according to their main activity codes is presented in the Table 5 below. In addition, all of the enterprises in question have a NACE code for manufacturing in addition to the main activity code.

Table 5. NACE code classification of enterprises

NACE Code	Descrıptıon Of Maın Actıvıty Code	Number Of Enterprıses
01	Plant Production Activities	11
10	Manufacture of Food Products	6
11	Beverage Manufacturing	4
13	Manufacture of Textile Products	2
14	Clothing Manufacturing	8
16	Manufacture of wood, wood products and cork products	15
17	Manufacture of paper and paper products	3
18	Printing and reproduction of recorded media	2
20	Manufacture of chemicals and chemical products	10
22	Manufacture of rubber and plastic products	13
23	Manufacture of other non-metallic mineral products	9
24	Base metal industry	3
25	Manufacture of fabricated metal products (except machinery and equipment)	25
26	Manufacture of computers, electronic and optical products	3
27	Electrical equipment manufacturing	16
28	Manufacture of machinery and equipment not elsewhere classified	49
29	Manufacture of motor vehicles, trailers and semi-trailers	33
30	Manufacture of other means of transportation	3
31	Furniture manufacturing	14
32	Other manufacturing	4
33	Installation and repair of machinery and equipment	3
41	Building construction	1
43	Special construction activities	1
46	Wholesale trade (except motor vehicles and motorcycles)	4
47	Retail trade (except motor vehicles and motorcycles)	1
61	Telecommunications	1
62	Computer programming, consulting and related activities	20
68	Real Estate Consulting	2
70	Administrative center activities; administrative advisory activities	1
71	Architecture and engineering activities; technical testing and analysis activities	3
72	Scientific research and development activities	5
74	Other professional, scientific and technical activities	1
81	Building-related services and landscaping activities	2

4.2. Other Data on Participating Enterprises

Other data on participating enterprises are analyzed in percentages in the Table 6 below.

Table 6. Business Information

Variable		N	%
TECHNOLOGY LEVEL			
	Low	86	31
	Medium Low	43	15
	Medium high	120	43
	High	29	11
SCALE			
	Micro	109	39
	Small	113	41
	Medium	56	20
PARTICIPANT GENDER			
Note: There are businesses with more than one participation	Male	233	80
	Female	58	20
FOUNDATION YEAR			
Note: Year of establishment data for 8 enterprises was not available.	Between 1-5 years	72	27
	Between6 -10 years	74	27
	Between 11-20 years	67	25
	Older than 20 years	57	21
EXPORT			
	YES	112	40
	NO	166	60
STRUCTURE OF THE ORGANIZATION			
	PRIVATE COMPANY	23	8
	LIMITED COMPANY	187	67
	INCORPORATED COMPANY	68	25
NUMBER OF EMPLOYEE PREMIUM DAYS			
Note: 254 enterprises have reached the number of premium days	0-3240 (1-9)	95	37
	3241-17640 (10-49	102	40
	>17640 (>50)	57	23
NET SALES REVENUE			
Notes: The number of enterprises whose financial data was accessed is 251	BETWEEN 0 AND 9,999 MILLION	92	37
	BETWEEN 10 AND 99,999 MILLION	131	52
	>100 MILLION	28	11

The categorization of the answers given to the variables in the questionnaire form as no (0) and yes (1) is presented in the Table 7 below.

Table 7. Responses to Variables

Variable	0 (no)	1 (yes)
PE1	15	263
PE2	35	243
PE3	64	214
PE4	27	251
EE1	80	198
EE2	64	214
EE3	104	174
EE4	68	210
SN1	134	144
SN2	94	184
SN3	139	139
FC1	113	165
FC2	58	220
FC3	110	168
FC4	58	220
BI1	43	235
BI2	46	232
BI3	98	180
USE1	69	209
USE2	107	171
USE3	104	174

In line with the Table 7, the survey questions were interpreted as follows

4.3. Performance Expectation

- I find CPS investment/use useful in my business life (for my business life) (PE1): 95% of the enterprises participating in the research find the use or investment of CPSs useful. This is a promising situation for the future of the country's industry due to the positive attitude of the users or prospective users towards CPSs, which are increasing their prevalence in the industry and IT sector day by day.
- CPSs investment increases (decreases) the competitiveness of my business/ my chances of accomplishing important things (tasks, jobs) (PE2): 87% of the enterprises participating in the research believe that CPSs have the function of increasing their competitiveness or their chances of accomplishing important tasks. The fact that CPSs, which started to become widespread in our country after 2020, are predominantly considered as an element of competition/critical task achievement in enterprises in a period of 3-4 years is a sign that in the short term, many more enterprises will be more interested in these systems in order to make their existence sustainable in their markets.
- Investing in CPSs helps me to practice my production and business processes (PE3): 77% of the enterprises participating in the research believe that CPSs help/can help them practice their production and managerial processes. This again shows that CPSs are perceived as a performance value by enterprises in the short term after they started to be used in our country.
- CPSs investment/utilization increases my productivity (PE 4): 90% of the enterprises participating in the research accept that CPSs increase productivity. This is an indication that CPSs will become more widespread in the manufacturing industry in the future.
- We use CPSs without difficulty/we know how and in which processes to invest (EE1): 71% of the businesses participating in the research do not have difficulty in using CPS and are conscious about investing. This shows that businesses are professional enough to use complex CPSs or that they are making efforts in this regard.
- My interaction with the use/investment of CPSs is clear and understandable (EE2): 77% of the businesses participating in the research have a positive interaction with CPSs. It is meaningful for businesses to be so interactive regarding the use of CPS, which has a very short history in our country, and is significant for the future of the country's industry.
- I find CPSs investment/investment processes/use easy (EE3): 62% of the businesses participating in the research find CPS investment/use easy. In the interviews, the businesses that expressed negative opinions on this issue generally stated that

they had difficulty in using these systems because they were expensive investments and the number of employees with IT competence was insufficient. It is anticipated that the perception of convenience will increase in the short term, as the efficiency gained from these systems and an established culture of use will be formed over time.

- It is easy for me to access the information/understand the investment processes required for CPSs investment (EE4): 76% of the businesses participating in the research stated that they did not have difficulty in understanding the CPS investment processes and accessing information. This again shows that there is a significant level of acceptance in our country's industry regarding the perception and acceptance of CPSs.

4.4. Social Impact

- My sectoral stakeholders think that I should invest in CPSs / they are satisfied and positively affected by our use (SN 1): 52% of the enterprises participating in the research stated that their sectoral stakeholders are encouraging the use of CPS. The reason for the low rate is that the competitors among the sectoral stakeholders tend to respond negatively due to their negative perceptions. However, despite this, the 52% positive impact on sectoral stakeholders is significant.
- Our most important (critical) customer groups think that I should use/invest in CPSs (SN2): 66% of the enterprises participating in the research stated that the use of CPS is perceived positively by customers due to customer satisfaction, being an intermediate / sub-industry enterprise, quality impact, cost reduction impact. On the other hand, 1/3 of the group, who stated that the issue has no effect on the final customer and that the customer is not affected by the use of CPS, stated that they generally prefer these systems because it facilitates their work and affects the competitiveness of the enterprise.
- Our most important (critical) supplier channels think that I should invest in/use CPSs (SN 3): Half of the enterprises participating in the research stated that their supply channels were positively affected by the use of CPS, while half stated that there was no effect. This situation shows that the connection of CPS utilization with supply chains is weak in our country. This is because the effects of CPS utilization such as capacity/cost/efficiency have a direct positive impact on supply channels due to both economies of scale and multiplier mechanism.

4.5. Facilitating Conditions

- I have the necessary resources for the investment/utilization of CPSs (FC1): 59% of the enterprises participating in the research state that they do not have resource shortages in terms of cyber physical utilization or investment. The fact that CPS investments are perceived as very expensive investments by enterprises has a great impact on the low rate. Institutions such as the Ministry of Industry and Technology and KOSGEB have highly qualified supports for CPS investments. It is important to expand these supports and ensure that more enterprises have access to these supports. Increasing facilitating conditions will increase the acceptance of CPS by enterprises.
- I have the necessary knowledge for CPSs investment/utilization (FC2): 79% of the enterprises participating in the research have the necessary knowledge about the investment and use of CPS. This ratio can be increased with more motivating and facilitating factors.
- CPSs technology is compatible with other technologies I use (FC3): 60% of the enterprises participating in the research stated that their existing technologies are compatible with CPS technology. The most important reason for the negative response of many enterprises is that CPSs, which are digital and information technology products, do not work in harmony with the semi-automation or manual technologies of the enterprises, creating idle capacity in some units and excessive workload in some units.
- I can get help from others when I have difficulties in using/investing in CPSs (FC4): 79% of the enterprises participating in the research stated that they can get help when they have difficulties while using or investing in the system. This shows that although CPS technology is new in our country, after-sales service/service and stakeholder interaction is quite strong.

4.6. Behavioral Intention

- I will continue to invest in/use CPSs in the future (BI1): 85% of the enterprises participating in the research stated that they will continue to invest in or use CPS and demonstrated a very strong will to accept and adopt the system. Most of those who gave negative answers gave negative answers because they believe that they have completed the necessary investments.
- I will always try to invest in/use CPSs in my business life (BI2): Again 83% of the enterprises participating in the research showed a strong acceptance that they will always use or continuously invest in CPSs. Businesses that rarely make these investments and achieve optimal profitability, on the other hand, showed a negative attitude towards the question.
- I plan to invest in/use CPSs frequently (BI3): 65% of the enterprises participating in the research stated that they will make these investments frequently or that they will use CPS frequently. The financial burden of CPS system investment is the main reason for the negative answers on this issue.

4.7. Usage

It was seen that 76% of the enterprises participating in the research use at least one CPS, 62% have the intention to use it and 63% have the need/want to reinvest in CPSs in the future.

Of the enterprises participating in the research:

- 43% stated that they use autonomous robots in production and management processes.
- 60% stated that they use industrial control systems.
- 59% stated that they use automation systems.
- 38% stated that they utilize sensor networks in their production systems.
- 26% stated that they utilize other CPSs.

Of the enterprises participating in the research:

- 50% stated that they frequently invested/will invest in autonomous robots.
- 62% stated that they frequently invested/will invest in industrial control systems.
- 63% stated that they frequently invested/will invest in automation systems.
- 40% stated that they frequently invest/will invest in sensor networks.
- 24% stated that they frequently invest/will invest in other CPSs.

The Structural Equation Model of the research conducted in line with the above data is presented below:

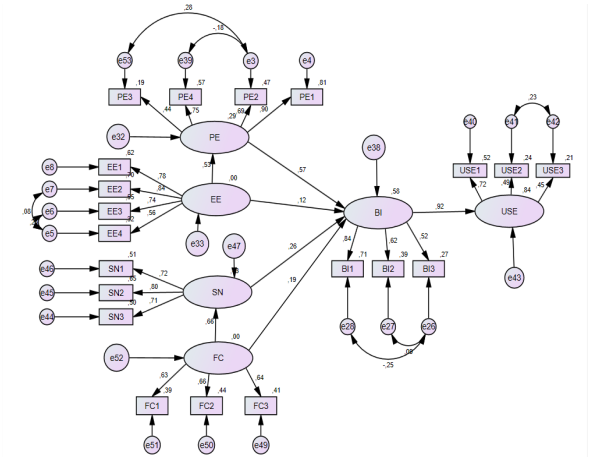

Figure 3. Structural Equation Model

The Structural Model represents an equation that quantifies the relationships between latent variables. In this context, exogenous latent variables within the model act as independent variables, while endogenous latent variables are included as dependent variables. As depicted in Figure 3, the structural model of the research comprises 6 latent variables: facilitating conditions, behavioral intention, social influence, usage, effort expectancy, and performance expectancy. The goodness of fit and acceptable values representing the effect between these latent variables (dependent and independent variables) were previously presented in Table 4. It is also seen in the confirmatory factor analysis (Figure 4) presented below. The generally accepted rule in path analysis of the relationships between the variables in the model is to use non-standard loadings [34]. However, since the evaluation is made with standard loadings, there are standard loadings on the model and in the Table 4.

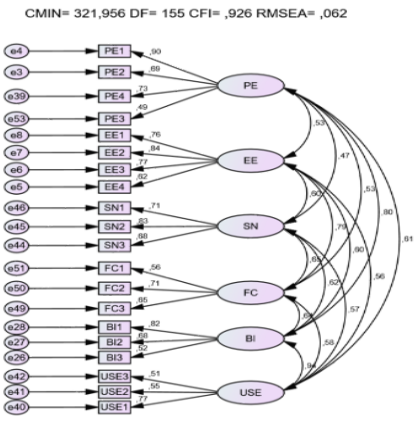

Figure 4. Confirmatory Factor Analysis

At this stage, the aim was to assess the fit of the factors identified through confirmatory factor analysis with the hypothesized factor structures. Measurement models seek to elucidate how a set of observable variables (utilized as measurement indicators) explain the latent variables defined. A first-level confirmatory factor analysis model was constructed to examine the latent variables within the model structure and to test the interrelationships between these variables using the AMOS program. (Figure 5).

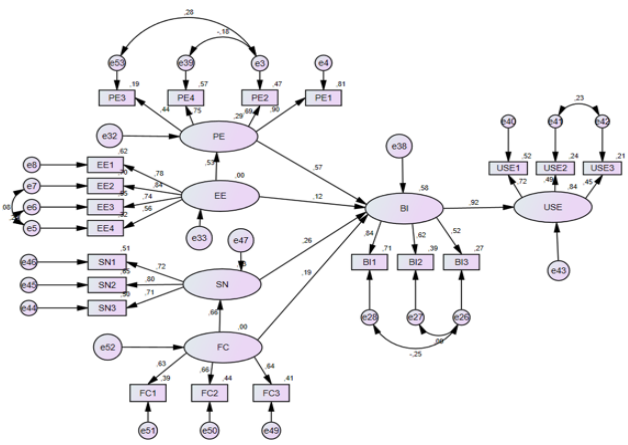

Figure 5. AMOS Output

4.8. Evaluation of Hypotheses as a Result of the Study Conducted within the Scope of UTAUT Model

- Unsupported Hypotheses:

First of all, when the unsupported hypotheses are examined; "Effort expectation has a positive effect on behavioral intention in the adoption of the CPS by the users." When the descriptive statistics are examined as a result of the unsupported hypothesis, it can be seen that the participants participated in the questions related to effort expectation. Likewise, when behavioral intention is examined, it is seen that there is a positive attitude. However, it was not found that effort expectancy had a statistically positive effect on behavioral intention. Another rejected hypothesis, "Facilitating conditions have a positive effect on behavioral intention in the adoption of the CPS by users." is another unsupported hypothesis. The participants gave hesitant answers about knowing the systems, having the necessary resources, and the compatibility of these systems with their existing technologies. Therefore, no positive or negative relationship between facilitating conditions and behavioral intention was found in the analysis.

- Supported Hypotheses:

H1 (Effort expectancy has a positive effect on performance expectancy in the adoption of CPS by users): In the study, it was observed that the participants responded positively to effort expectancy and performance expectancy in parallel. Businesses see these systems as practical, useful and competitive to the extent that they know, adopt, interact and find them easy. In this direction, it is important that businesses in our country should be more informed about CPSs and that the public sector should determine effective policies for the dissemination of these systems.

H2 (Facilitating conditions in the adoption of CPS by users have a positive effect on social impact): As a result of the research, it is seen that the fact that the enterprises are aware of CPSs, have the resources to invest, the adaptation of these systems with their production structures and the strong solution partners for these systems bring about a positive impact on the social environment of the enterprise from suppliers to customers and sectoral stakeholders. This shows that the use of CPS effectively activates the economic multiplier and multiplier.

H3 (Performance expectation has a positive effect on behavioral intention in the adoption of CPS by users): According to the research results, businesses tend to use and invest in CPSs to the extent they evaluate them as a practical, useful and competitive element.

H5 (Social influence has a positive effect on behavioral intention in the adoption of the CPS by users): When the answers given by the participants in the research are correlated, the encouragement and support of the stakeholders, suppliers and customers of the enterprises positively affects the use of CPS by the enterprises and their reinvestment in these systems.

H7 (Behavioral intention in the adoption of the CPS by users has a positive effect on the use of the CPS): In the research, it was determined that the behavioral intentions of the businesses (willingness to use / intention to invest) resulted in usage and there was a direct relationship between behavioral intention and CPS use.

5. Conclusion

Information and production technologies have developed greatly in recent years. For businesses to stay out of these developments is, first of all, a threat to their existence. Businesses that cannot keep up with developments fail to meet the needs of the market and become unsustainable. CPSs, which are the most intense reflection of information and production technology on businesses, provide businesses with the opportunity to continue their existence by providing competitive advantage. While some of the businesses prefer to use CPS to benefit from the opportunities of modern technology, some may resist the use of CPS.

The existence of positive or negative reactions to the use of digital technologies is seen in the manufacturing industry as in every field. In this study, the behavior of manufacturing industry enterprises towards the use of CPS was tried to be predicted using the UTAUT. The analysis results of the data obtained from a face-to-face survey conducted with 278 businesses in Sakarya Province, which is developing more and more as an industrial city in Turkey, show that the UTAUT Model can be used to predict the CPS usage behavior of businesses.

According to the findings obtained from the analysis, (1) Effort expectation has a positive effect on performance expectation in the adoption of the CPS by users. The relationship between these two concepts has been particularly emphasized in motivation theories such as Vroom's Expectancy Theory. According to this theory, individuals' motivation is based on the relationship between their effort and performance expectations and the value of the reward they will receive as a result of achieving their goals. That is, an individual's ability to exert the effort required to achieve a particular goal and to evaluate the likelihood of achieving that goal affects their motivation and performance [46].

Another conclusion is that (2) Facilitating conditions in the adoption of the CPS by users have a positive impact on social impact. As a result, the multitude of facilitating conditions for businesses to use CPSs also creates a positive impact on the social environments of businesses. Facilitating conditions can therefore increase the likelihood of social impact occurring.

Another result obtained from the research is (3) Performance expectation has a positive effect on behavioral intention in the adoption of the CPS by users. The relationship between these two concepts is emphasized in theories such as Ajzen's Behavioral Intention Model (Theory of Planned Behavior) and Fishbein and Ajzen's Theory of Reasoned Action. According to these theories, individuals' behavioral intentions are determined by their attitudes, norms, and perceived behavioral control factors. One of these is performance expectation [47,48]. Therefore, there is a strong relationship between performance expectation and behavioral intention.

Another significant finding from the study is (4) that social influence positively impacts behavioral intention in the adoption of the CPS by users. Social influence is operationally defined as the individual's perception of the belief that influential individuals endorse the adoption of the new system. [49]. Social influence was developed as the counterpart of subjective norm and social norm variables in previous behavioral theories [50]. Within the framework of CPS, many businesses tend to make their decisions to adopt these systems dependent on the recommendations of others.

Another result of the research is that (5) Behavioral intention has a positive effect on the use of the CPS in the adoption of the CPS by users. This variable was expected to positively affect intention and usage. When businesses perceive CPS as useful and have a positive attitude towards its use, they will develop an intention to use CPS technology. If businesses have intentions to use CPS technologies, this will be reflected as usage behavior.

According to the research, unexpected research results revealed that Effort expectation does not have a positive effect on behavioral intention in the adoption of the CPS by users, and that facilitating conditions do not have a positive effect on behavioral intention in the adoption of the CPS by users.

In the research study, in line with the answers given to the survey questions, the observations made in the enterprises and the evaluations of the enterprise officials on the subject, it has been determined that there are some obstacles to the widespread use of CPS in our country. First of all, investments in CPS technologies are expensive investments that SME-scale enterprises will be financially inadequate due to lack of capital accumulation. At this point, it is suggested that public resources should be channeled to such investments in the form of refundable or non-refundable support. It was also observed during the research process that SMEs' level of knowledge and awareness on CPSs is insufficient. The CPS concept is still new for many businesses in Turkey. Therefore, it can be said that there is not yet sufficient knowledge and awareness about the advantages of CPS.

In terms of regulations and standards related to CPS, the desired point has not yet been reached in our country. At this point, legal uncertainties regarding the use of CPS are still a risk. The traditional business culture of the Turkish industry also shows the existence of a resistance mechanism in the industrial sector against innovations. In this context, it can also be mentioned that there is an unwillingness to digital transformation in enterprises. In addition, one of the most important problems is that many enterprises do not have a qualified workforce capable of implementing and managing CPS technologies.

Such obstacles negatively affect the acceptance of CPS by enterprises in Turkey. However, with technological progress, awareness raising studies, incentives and support policies, the level of acceptance of CPSs in Turkey can reach the desired points.

Declaration of Conflict of Interests

The authors declare that there is no conflict of interest. They have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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