

# Digital Infrastructure Transformation in the Public Sector: Explaining IPv6 Adoption Through the UTAUT Framework

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**Abstract**—The Internet, as a product of advanced technological development, has evolved through a dynamic and synergistic process. However, its original architecture was not designed to accommodate such unprecedented growth, resulting in fundamental limitations, particularly in the addressing architecture. The exhaustion of the IPv4 address space has emerged as a major sustainability problem for the Internet. To overcome this limitation, Internet Protocol version 6 (IPv6), which provides a significantly larger address space and additional technical capabilities, was standardized by the Internet Engineering Task Force (IETF) in 1998. Despite its technical superiority, IPv4—standardized in 1981—continues to dominate operational networks, indicating that IPv6 adoption has not yet reached expected levels. This study examines the factors influencing IPv6 adoption in public institutions using the Unified Theory of Acceptance and Use of Technology (UTAUT) framework. Survey data were collected from 456 managerial and technical personnel employed in public institutions in Türkiye. Structural Equation Modeling (SEM) was conducted using SPSS and AMOS software. The findings reveal that facilitating conditions significantly affect both effort expectancy and performance expectancy. Furthermore, effort expectancy and performance expectancy positively influence behavioral intention, which in turn has a direct effect on actual IPv6 usage. These results emphasize the critical role of organizational and structural factors in accelerating IPv6 transition within the public sector. The findings further demonstrate that next-generation network deployment represents not only an engineering challenge but also a socio-technical transformation process shaped by human and organizational factors.

**Keywords**—IPv6; UTAUT; Structural Equation Modeling (SEM); Technology Acceptance Models; internet and network technologies

## I. INTRODUCTION

Digital transformation has become a central priority in modern public administration, requiring not only advanced digital services but also a robust, scalable, and sustainable network infrastructure [1], [2]. At the core of this infrastructure lies the Internet Protocol (IP), which enables global connectivity and underpins all digital communication [3]. Following the near-total depletion of IPv4 address pools at global and regional levels, the transition to IPv6 has evolved from a technical upgrade into a strategic necessity for supporting long-term digital growth [4], [5]. Emerging technologies such as 5G, the Internet of Things (IoT), and smart city applications increasingly

depend on the scalability and architectural flexibility offered by IPv6-based networks [6]. Despite the well-documented technical advantages of IPv6, including an almost limitless address space, enhanced security mechanisms, and simplified network management, its global adoption remains inconsistent [7]. This disparity, often termed the IPv6 adoption paradox in the mature adoption [9]. This persistent gap suggests that the barriers to IPv6 transition are not purely technical but are strongly associated with organizational and behavioral factors. Accordingly, large-scale IPv6 deployment should be understood not merely as a networking upgrade, but as a digital infrastructure transformation process requiring both engineering readiness and institutional preparedness. The existing literature on IPv6 has predominantly focused on protocol specifications, performance comparisons, and technical transition mechanisms such as dual-stack and tunneling [10], [11]. While these studies provide valuable engineering insights, they offer limited explanations for why technically mature solutions encounter resistance during organizational implementation. In particular, empirical research addressing the socio-technical dimensions of IPv6 transition—especially from the perspective of IT professionals responsible for planning, deployment, and maintenance in public institutions remains limited. Addressing these behavioral and perceptual barriers is, therefore, critical to understanding the human dimension of digital infrastructure transformation. To address this gap, this study employs the Unified Theory of Acceptance and Use of Technology (UTAUT) framework to examine the determinants of IPv6 adoption in public institutions. Recognizing that infrastructure technologies differ fundamentally from voluntary, user-facing information systems, the UTAUT model is adapted to reflect the institutional context of public-sector infrastructure transitions. Specifically, the model emphasizes facilitating conditions as an antecedent shaping internal cognitive perception—namely, effort expectancy and performance expectancy—while excluding social influence, given the mandatory and policy-driven nature of technology adoption in public organizations. This approach allows infrastructure transition to be analyzed as a socio-technical adoption process rather than a purely technical deployment decision. The contributions of this study are threefold. First, it is among the few empirical investigations examining IPv6 adoption within the public sector of a developing economy. Second, it extends technology acceptance research by demonstrating how facilitating conditions indirectly influence adoption through users' cognitive perceptions in the context of deep infrastructure technologies. Third, it provides

actionable insights for policymakers and IT managers, including the importance of structured training programs and capacity-building initiatives aimed at reducing perceived effort and accelerating the transition to next-generation Internet protocols.

The remainder of this study is organized as follows: Section II reviews the theoretical background and related literature. Section III presents the research model and hypotheses. It also outlines the methodology. Section IV reports the empirical findings, and discussion of implications, limitations, and directions for future research. Section V concludes the study.

## II. BACKGROUND

### A. Foundations and Evolution of the Internet

Computer networks form the backbone of modern information systems by enabling communication between devices through standardized protocols and layered architectures such as the OSI model [12]. These networks range from local to wide-area structures and support essential operations such as data transmission, routing, and resource sharing. Ethernet technology serves as a widely adopted standard for network infrastructure development across different network scales [13].

The evolution of the Internet has been shaped by early developments such as ARPANET and the adoption of TCP/IP protocols, which enabled interoperability across different network systems [14], [15]. Over time, the expansion of internet usage introduced challenges related to scalability and address management, leading to the development of supporting systems such as DNS [16], [17]. These developments transformed the internet into a global infrastructure supporting communication, information exchange, and digital services [18].

### B. Internet Protocol and Limitations of IPv4

The Internet Protocol (IP) is the main network-layer protocol that addresses uniquely devices on the internet and allows routing of data packets between networks [2]. Its primary functions are logical addressing, packet encapsulation, routing, and fragmentation. IPv4 uses a 32-bit addressing scheme which translates theoretically to around 4.3 billion unique addresses. However, with the fast growth in mobile devices, cloud computing services and Internet of Things (IoT) applications, this address space has become inadequate. The last allocation by IANA of IPv4 address blocks to Regional Internet Registries in 2011 was a major step as it indicated that IPv4 addresses were exhausted worldwide [19]. Network Address Translation (NAT) and Carrier-Grade NAT (CGNAT) have been used as short-term solutions; however, they do not support the end-to-end connectivity principle, increase the complexity of the network, and bring performance and security problems according to studies conducted by Donley et al. [6] and Richter et al. [7]. These limitations clearly indicate that IPv4 can no longer fulfill modern internet requirements [8].

### C. IPv6 and the Next-Generation Internet Architecture

IPv6 was developed by the Internet Engineering Task Force to provide a solution for the limitations in addressing and architecture that IPv4 presented [3]. It is structured with 128 bits for its address space which means theoretically it can support

about  $3.4 \times 10^{38}$  addresses, hence solving any problems related to exhaustion of addresses permanently [20]. Some important technical benefits of IPv6 are a streamlined packet header, native support for IPsec, SLAAC, improved multicast and anycast features, and removal of the requirement for NAT [21], [9]. All these make room for more secure networks with better scalability and manageability, especially in large public sector network infrastructures. However, despite these technical advantages, the success of IPv6 deployment depends not only on protocol capabilities but also on organizational capacity, user readiness, and institutional support mechanisms.

### D. Technology Adoption and the UTAUT Model

The adoption of technological innovations is a process that takes place within the framework of several dimensions, namely individual perceptions, organizational structures, and social interactions. Theoretical models developed to explain this process include the Theory of Reasoned Action (TRA), the Theory of Planned Behavior (TPB), Innovation Diffusion Theory (IDT), and Technology Acceptance Model (TAM) [22], [23], [24]. These models were developed independently and each address only part of the adoption process. The Unified Theory of Acceptance and Use of Technology (UTAUT) was introduced by Venkatesh et al. [11] as a synthesis of eight previous models, providing a high level of theoretical integration for technology acceptance and use. The model explains behavioral intention and actual use through four constructs: performance expectancy, effort expectancy, social influence, and facilitating conditions. UTAUT has been chosen as the framework for analysis in this study on IPv6 transition because it explains about 70% of variance, includes moderator variables such as age, gender, experience, and voluntariness of use, as well as organizational factors. By applying UTAUT to a foundational network technology, this study extends technology acceptance research beyond user-facing systems to deep digital infrastructure environments.

## III. RESEARCH MODEL AND HYPOTHESES

In this study, the Unified Theory of Acceptance and Use of Technology (UTAUT) is adopted as the theoretical framework to identify the factors influencing the adoption of IPv6 technology in public institutions in Turkey. UTAUT provides a comprehensive approach that is widely used to explain individuals' perceptions and intentions toward technology use [11]. Within the scope of this study, the research model focuses on facilitating conditions, effort expectancy, performance expectancy, behavioral intention, and actual use behavior. The social influence construct was not included, as IPv6 adoption in public institutions is predominantly driven by formal mandates and organizational policies rather than peer-based or voluntary social dynamics. Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM) were conducted using SPSS AMOS. Unlike voluntary technology adoption contexts, IPv6 implementation in public institutions is largely driven by regulatory frameworks and institutional directives. Therefore, the social influence construct, which reflects interpersonal or peer effects, is considered less relevant in this context. Similarly, voluntariness of use is inherently limited, as employees are expected to comply with organizational technology policies. For this reason, the UTAUT model was conceptually adapted by

excluding social influence and related moderating variables, allowing the analysis to focus on organizational and cognitive determinants of adoption. Social influence does not always emerge as a significant determinant even though it is part of UTAUT framework when dealing with highly specialized contexts such as institutional technical infrastructure transitions. By excluding this particular dimension, conceptual focus increases while improving model fit in an organizational context with this specific sample size. This modeling decision agrees with findings reported in similar contexts within literature [25].

### A. Expected Contributions of the Study

The results of this research are expected to enhance understanding of the transition processes to IPv6 in public institutions and help identify and ameliorate those factors that delay or impede such a transition. Since IPv6 is an important component of infrastructure for the digital transformation of public institutions, its accelerated adoption can be facilitated by empirical evidence from managerial and technical personnel perspectives. The results should indicate organizational and technical areas that need improvement for a better IPv6 transition process. The UTAUT model used in this study assesses how much the behavioral intention and actual usage behavior are determined by performance expectancy, effort expectancy, and facilitating conditions. Therefore, it attempts to get specific information about priority areas for public institutions concerning IPv6 adoption. In this sense, this study not only informs about the approaches taken by public

institutions toward IPv6 but also helps in strategic decision-making concerning wider technological as well as digital transformation efforts. In addition, it attempts to be an original contribution to literature where very few empirical studies have been undertaken regarding the transition from IPv4 to IPv6 in the course of digital transformation. The proposed structural model is also anticipated as one of the key outcomes of this research to be a reference model for future studies carried out under similar organizational contexts. Unlike prior IPv6 studies focusing on protocol performance or transition mechanisms, this research conceptualizes IPv6 migration as an organizational and behavioral transformation process within public digital infrastructure.

### B. Measurement Instruments

All constructs in this study were measured using validated scales adapted from prior UTAUT literature. The survey instrument consists of items measuring performance expectancy, effort expectancy, facilitating conditions, behavioral intention, and actual use. The measurement structure of the study, including constructs, item codes, and sources, is presented in Table I. The factor structure of the scales has been previously validated in the literature; therefore, the measurement model was assessed using confirmatory factor analysis (CFA) to ensure construct validity and consistency. All items were measured using a five-point Likert scale (1 = Strongly disagree, 5 = Strongly agree).

TABLE I. MEASUREMENT CONSTRUCTS AND ITEMS

Construct	Code	Measurement Item	Source
Performance Expectancy (PE)	PE1, PE2, PE3, PE4	Improves task efficiency; enhances organizational performance; strengthens cybersecurity; supports effective process management.	Venkatesh et al. (2003)
Effort Expectancy (EE)	EE1, EE2, EE3, EE4	Easy to learn and use; transition process is simple and understandable; requires little effort; less complex than existing systems.	Venkatesh et al. (2003)
Facilitating Conditions (FC)	FC1, FC2, FC3, FC4	Infrastructure support available; sufficient technical knowledge; technical support accessible; training and guidance provided.	Venkatesh et al. (2003)
Behavioral Intention (BI)	BI1, BI2, BI3, BI4	Intend to use IPv6; willing to participate in transition; committed to using IPv6; support its future adoption.	Venkatesh et al. (2003)
Actual Use (AU)	AU1, AU2, AU3	Regular usage; increasing adoption; integrated into daily processes.	Venkatesh et al. (2003)

### C. Research Model

The conceptual model developed in this study is intended to assess the IPv6 adoption process in public institutions within the framework of the Unified Theory of Acceptance and Use of Technology (UTAUT). This model comprises five core constructs—Performance Expectancy, Effort Expectancy, Facilitating Conditions, Behavioral Intention, and Actual Use Behavior—designed to explicate employees’ perceptions and usage behavior regarding IPv6 technology. These constructs together represent individual cognitive evaluations as well as organizational and technical conditions through an integrated approach. In the model, Performance Expectancy represents employee perceptions that IPv6 technology will improve organizational efficiency, network performance, and business processes. Effort Expectancy refers to perceived ease of learning and using IPv6 while Facilitating Conditions represent institutional technical infrastructure, training opportunities, technical support mechanisms, and overall organization readiness. These variables are assumed to have a direct effect on employees’ Behavioral Intention toward using IPv6 technology.

Behavioral Intention is what reflects individuals’ willingness to use IPv6; it serves as the main determinant of Actual Use Behavior in this model. Furthermore, Facilitating Conditions are assumed to have a direct effect on actual usage independent of behavioral intention. Besides that, following previous studies based on UTAUT, Effort Expectancy is hypothesized to positively influence Performance Expectancy; this linear relation is explicitly specified in the model. Prior to data collection, approximately 600–700 IT personnel working in public institutions were contacted. The final sample consists of 456 respondents, comprising managerial and technical IT personnel employed in state universities in Türkiye. Survey items were adapted from measurement scales used in prior studies. This study adopted a quantitative research design using the survey method for data collection. The survey was administered between February 1, 2025, and July 24, 2025. Participants were selected based on convenience sampling method of accessibility. To ease participation, the survey was conducted online via Google Forms. The data collection instrument that was developed to test the research model consists of a total of 26 items. Besides seven questions capturing

demographic characteristics of participants, four items each for Performance Expectancy measurement, Effort Expectancy measurement, Facilitating Conditions measurement, Behavioral Intention measurement, and three items measuring Actual Use Behavior were included in the survey. The measurement items were based on scales widely used in UTAUT literature. The theoretical factors affecting the transition process of IPv6 in public institutions are described by the conceptual research model developed herewith. This model serves as an analytical basis for testing the hypotheses proposed in this study. The research model can be seen in Fig. 1.

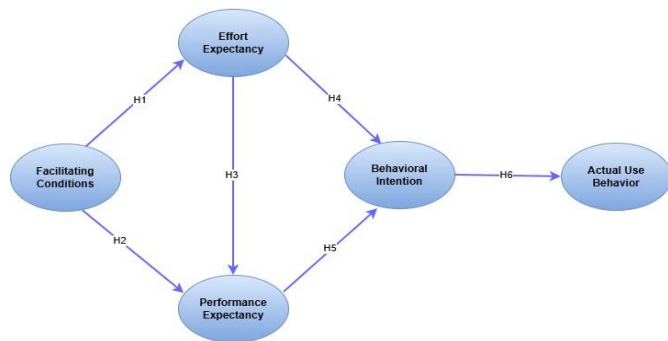


Fig. 1. Our research model.

The measurement scales used in this study were adapted from previously validated instruments in the literature. As presented in Table II, all constructs in the research model—including performance expectancy, effort expectancy, facilitating conditions, behavioral intention, and actual use behavior—were measured using multi-item scales. Demographic information was collected through seven items, while the remaining constructs were measured using between three and four items each. All scale items were derived from the Unified Theory of Acceptance and Use of Technology (UTAUT) framework and adapted to the context of IPv6 adoption in public institutions [26].

TABLE II. MEASUREMENT SCALES USED IN THE RESEARCH MODEL AND THEIR SOURCES.

Scales	Number of Items per Construct	Source
Demographic Information	7	[26]
Performance Expectancy	4	[26]
Effort Expectancy	4	[26]
Facilitating Conditions	4	[26]
Behavioral Intention	4	[26]
Actual Use Behavior	3	[26]

#### D. Hypotheses

The model primarily aims to test the hypotheses articulated below and to analyze the results obtained.

H1: Facilitating conditions have a positive and significant impact on effort expectancy in learning and using IPv6 technology by employees of public institutions.

H2: Facilitating conditions have a positive and significant impact on performance expectancy as perceived by employees in terms of improving organizational performance with IPv6 technology.

H3: Effort expectancy has a positive and significant impact on performance expectancy as perceived by employees in terms of improving organizational performance with IPv6 technology.

H4: Effort expectancy has a positive and significant impact on the behavioral intention of employees toward using IPv6 technology.

H5: Performance expectancy has a positive and significant impact on the behavioral intention of employees toward using IPv6 technology.

H6: Behavioral intention has a positive and significant effect on the actual usage behavior of IPv6 technology in public institutions.

#### E. Data Analysis Methods

The data analysis was done in a specific order, taking into account how each statistical step influenced the following analyses. The first step included data cleaning, which involved checking for missing values, outliers, and any possible errors in data entry. Normality tests were then applied to determine if the data met the requirements for analysis. The multicollinearity among variables was checked through multiple linear correlation analysis. Reliability analysis checked the internal consistency of the scales, and validity analysis tested the measurement constructs. Finally, correlation analysis was performed to see how different variables relate to each other. In this study, independent variables included demographic information, performance expectancy, effort expectancy, facilitating conditions, and behavioral intention; however, the dependent variable was actual usage behavior. Data analyses were carried out with SPSS 20.0 and AMOS 24.0 software packages. The proposed hypotheses were tested using Structural Equation Modeling (SEM). The results from these analyses are discussed under appropriate subheadings within the context of the research model.

#### F. Reliability Analysis

Reliability analysis is a statistical approach that assesses the internal consistency among scale items and gauges how well a scale captures the true essence of what it intends to measure, both accurately and consistently. The main focus was on Cronbach's alpha coefficient, which varies between 0 and 1. As the alpha value approaches 1, this indicates stronger internal consistency for the scale. The ranges of alpha coefficients interpreted in this research were based on definitions by other authors [27]–[29] and are presented below: A coefficient within the interval 0.00 ; 0.40 implies that the scale is unreliable. If it falls within the range of 0.40 ; 0.60, then there is low reliability for that scale. A moderate reliability would be indicated by a coefficient from 0.60 up to but not including 0.80, while high reliability would be signified when the value is above 0.80 up to 1.00. Table III displays Cronbach's alpha values for factors and their respective sub-items as utilized in this study.

TABLE III. CRONBACH'S ALPHA COEFFICIENTS FOR THE FACTORS

Factor	Cronbach's Alpha
Performance Expectancy	0.902
Effort Expectancy	0.881
Facilitating Conditions	0.770
Behavioral Intention	0.875
Actual Use Behavior	0.845

The coefficients of Cronbach's alpha computed for the factors and their respective items reveal a high degree of reliability, which is indicative of very strong internal consistency of the scale. It can be seen from Table III that Performance Expectancy has the highest internal consistency (= 0.902) and Facilitating Conditions has the lowest consistency (= 0.770).

G. Validity Analysis

Validity analysis is the determination of whether a measuring instrument or test truly and appropriately measures the construct that it claims to measure [30], [31]. Validity makes research results meaningful, relevant, and credible by permitting

correct inferences to be made and sound decisions based on the trustworthiness of the results [32].

H. Confirmatory Factor Analysis

Confirmatory Factor Analysis (CFA) is an essential analysis technique for the evaluation of the construct validity of scales and questionnaires. After the theoretically proposed factor structure has been specified, CFA will indicate how well the observed data fit this structure. It assesses factor loadings, factor correlations, and model parameters to determine the extent to which a proposed model aligns with observed data. CFA, thus, is very important in determining whether or not a measurement instrument adequately and accurately measures its intended constructs [33, p. 2]. In this work, CFA was performed for construct validity testing. The factor structure obtained is illustrated in Fig. 2.

The CFA showed that all factor loadings were greater than 0.5, thus confirming their adequacy [34], and the model fit indices met the recommended thresholds. No misfits were detected, and consequently, no items or factors needed to be removed. Table IV provides a summary of the definitions of the fit indices, their acceptable ranges, and the values that resulted from this analysis.

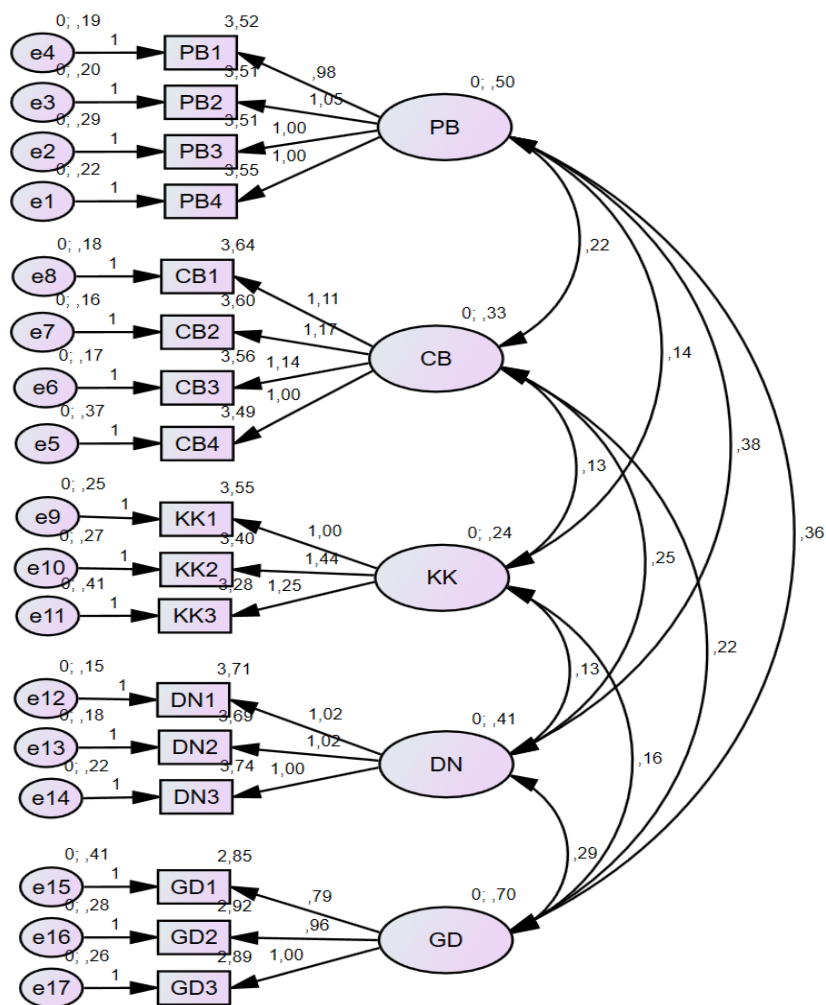


Fig. 2. Our SPSS AMOS CFA (Confirmative Factor Analysis). Source: Author's own illustration generated in SPSS AMOS.

TABLE IV. MODEL FIT INDICES

Factor	Description	Acceptable Fit	Cronbach's Alpha
CMIN/DF	Reduces sample sensitivity and reflects the overall fit of the model to the data in a more balanced way.	$2.00 \leq \text{CMIN/DF} \leq 5.00$	2.607
CFI	Assesses the fit by comparing the model with an independent model.	$0.90 \leq \text{CFI} \leq 0.95$	0.963
RMSEA	Indicates how closely the model approximates the actual data.	$0.05 \leq \text{RMSEA} \leq 0.10$	0.059
PClose	It is the standardized measure of the differences between the model and the observed data.	$0.05 \leq \text{SRMR} \leq 0.10$	0.038

The Confirmatory Factor Analysis (CFA) results show that the model has a good fit. The CMIN/DF value was calculated as 2.607, the CFI value as 0.963, the RMSEA value as 0.059, and the PClose value as 0.033. All these indices fall within the acceptable ranges recommended in the literature [35], [36].

These results indicate that the proposed measurement model fits the observed data very well and confirms the validity of the construct structure. Factor loadings, R<sup>2</sup> values, AVE, CR, and MSV are given in Table V as indicators for assessing reliability and validity for constructs being measured.

TABLE V. VALIDITY VALUES OF THE SCALE ITEMS

Factor	Item	Factor Weight	R <sup>2</sup>	AVE	CR	MSV
Performance Expectancy	PB1	0.848	0.719	0.679	0.902	0.694
	PB2	0.857	0.735			
	PB3	0.796	0.633			
	PB4	0.837	0.700			
Effort Expectancy	CB1	0.829	0.688	0.656	0.883	0.473
	CB2	0.863	0.745			
	CB3	0.845	0.714			
	CB4	0.690	0.476			
Facilitating Conditions	KK1	0.696	0.485	0.534	0.774	0.226
	KK2	0.801	0.642			
	KK3	0.690	0.476			
Behavioral Intention	DN1	0.720	0.736	0.700	0.875	0.694
	DN2	0.840	0.705			
	DN3	0.811	0.658			
Actual Use Behavior	GD1	0.720	0.518	0.649	0.846	0.367
	GD2	0.834	0.696			
	GD3	0.856	0.732			

Factor loadings were between 0.690 and 0.863 and all were above the minimum threshold of 0.50, which indicates that item reliability is strong. Convergent and discriminant validity are assessed with the help of the coefficient of determination (R<sup>2</sup>), Average Variance Extracted (AVE), Composite Reliability (CR), and Maximum Shared Variance (MSV). Values for all factors about their items are presented in Table V; results here confirm that high reliability and construct validity exist across all constructs for the measurement model.

I. Factor Loadings and Item-Explained Variance

All item factor loadings are between 0.690 and 0.857 as seen in the table. In the structural equation modeling literature, factor

loadings that exceed 0.50 suggest that items sufficiently represent their respective latent constructs [37], [38]. Therefore, it can be concluded that all items have acceptable loadings. The R<sup>2</sup> values indicate that the percentage of variance explained by each item ranges from 0.476 to 0.745. This finding confirms that a considerable part of the variance for each item is explained by its related latent variable, which proves sufficient measurement power [39].

J. Convergent Validity

Convergent validity was evaluated via Average Variance Extracted (AVE) values. A value of AVE greater than 0.50 is documented in the literature as indicating that more than half the variance in the indicators is accounted for by the latent construct, hence establishing convergent validity [40]. In this particular study:

- Performance Expectancy held an AVE of 0.679;
- Effort Expectancy has an AVE of 0.656;
- Facilitating Conditions bear an AVE equal to or above 0.534;
- Behavioral Intention carries an AVE of 0.700;
- Actual Use has an AVE at 0.649.

All these are above the 0.50 cut-off point and hence, convergent validity is established for all the constructs.

K. Internal Consistency and Composite Reliability

The evaluation of the reliability of the scales was done through Composite Reliability. A CR value greater than 0.70 is an indication of adequate internal consistency of the construct as per [37]. The results from the analysis indicated that the CR values fell within a range from 0.774 to 0.902, which further confirmed that all constructs had high reliability.

L. Discriminant Validity

Discriminant validity was evaluated based on the Maximum Shared Variance (MSV) criterion. According to Fornell and Larcker's guideline, discriminant validity is established if the MSV of a construct is lower than its Average Variance Extracted (AVE) [40]. In this study, all constructs satisfy the condition MSV < AVE, thus proving the statistical distinctiveness of the constructs and confirming that discriminant validity is achieved.

M. Overall Evaluation

Based on the results: All items have acceptable and strong factor loadings. The measurement model has convergent validity (AVE). Constructs exhibit high internal consistency and reliability (CR). Discriminant validity (MSV < AVE) is confirmed for all constructs. In brief, the measurement model

applied in this study fulfills all SEM literature requirements concerning validity and reliability.

*N. Discriminant Validity Assessment*

Discriminant validity is one of the ways to test the model’s validity. It proves that each construct is unique by showing that they are not related or dependent on each other [41]. To assess this, both Fornell–Larcker and HTMT analyses were performed. The results from the Fornell–Larcker test are shown in Table VI.

TABLE VI. FORNELL-LARCKER TEST

Factors	PB	CB	KK	DN	GD
Performance Expectancy	<b>0.835</b>				
Effort Expectancy	0.546	<b>0.810</b>			
Facilitating Conditions	0.411	0.476	<b>0.731</b>		
Behavioral Intention	0.833	0.687	0.421	<b>0.837</b>	
Actual Use Behavior	0.606	0.458	0.387	0.539	<b>0.805</b>

The square root of the average variance extracted for each construct should, according to Fornell and Larcker, be greater than the correlation coefficients of that construct with other constructs [40]. Results indicated that all constructs satisfy this condition; therefore, discriminant validity is achieved. HTMT analysis is another approach used to check discriminant validity. The output from the HTMT analysis will be shown in Table VII below:

TABLE VII. HTMT TEST

Factor	PB	CB	KK	DN	GD
Performance Expectancy					
Effort Expectancy	0.545				
Facilitating Conditions	0.418	0.478			
Behavioral Intention	0.832	0.686	0.427		
Actual Use Behavior	0.594	0.478	0.416	0.525	

Henseler et al. developed the HTMT criterion, which states that if values are lower than 0.85 or 0.90, then discriminant validity is achieved [42]. A review of the results reveals that all values fall under 0.85; thus, this confirms the existence of discriminant validity.

*O. Correlation Analysis*

Correlation analysis is a statistical method for assessing the linear relationship between two continuous variables. The strength and direction of the linear relationship are defined by the correlation coefficient, which varies from -1 to +1. A positive coefficient indicates a direct relationship between variables, whereas a negative coefficient indicates an inverse relationship.

The closer the coefficient is to zero, the weaker the relationship; as it approaches ±1, the relationship becomes increasingly linear [43]. Correlation analysis was therefore performed in this study to assess how these factors relate with one another and whether such relationships are significant or not. Results are shown in Table VIII.

TABLE VIII. FACTOR CORRELATION ANALYSIS

Factor	PB	CB	KK	DN	GD
Performance Expectancy	1				
Effort Expectancy	0.546	1			
Facilitating Conditions	0.411	0.476	1		
Behavioral Intention	0.833	0.687	0.421	1	
Actual Use Behavior	0.606	0.458	0.387	0.539	1

*P. Correlation Analysis Among Factors*

In this study, the relationships between latent variables were tested using the correlation coefficients derived from confirmatory factor analysis. The size and sign of the correlation coefficients were assessed in order to know about the level of linear relationships existing among these factors. In SEM and behavioral sciences, the following threshold values are generally used for interpreting correlation coefficients: 0.10–0.29 low; 0.30–0.49 moderate; 0.50–0.69 moderate-high; and 0.70 and above high correlation [44], [37]. The analysis results indicated that correlation coefficients were above 0.40, which means that there is a statistically significant and moderately strong linear relationship between the factors. The range of values taken by these correlation coefficients between factors fell from 0.387 to 0.833. There is a moderate-high positive relationship between Performance Expectancy and Effort Expectancy ( $r = 0.546$ ). Performance Expectancy has a high-level relationship with Behavioral Intention ( $r = 0.833$ ). There is a moderate-high positive relationship between Effort Expectancy and Behavioral Intention ( $r = 0.687$ ). The relationships of Facilitating Conditions with other factors are at a moderate positive level ( $r = 0.387–0.476$ ), which indicates that this construct creates meaningful but not very strong connections with the other variables. The correlation coefficient between Behavioral Intention and Actual Use is moderate-high positive ( $r = 0.539$ ). All the correlation coefficients are positive and above 0.30, which means that statistically significant and theoretically consistent linear relationships exist among the factors [38].

*Q. Structural Equation Modeling*

Structural Equation Modeling (SEM) is a common method for estimating parameters and testing hypotheses. It serves theory development by explaining variance through linear equations comprising observed and latent variables. SEM facilitates the simultaneous assessment of measurement models and theoretical constructs. It also allows the integrated evaluation of the measurement model, which includes analyses of reliability and validity, with the structural model used to test hypotheses. In this sense, SEM constitutes a robust statistical tool that helps to test holistically any relationships between independent, mediating, moderating, and dependent variables so as to further develop theoretical models [45]. Therefore, SEM was used to analyze direct as well as indirect relationships among the variables stipulated above. The model resulting from this analysis was then interpreted in order to assess both research hypotheses and the validity of the theoretical framework. The structural model generated from this analysis is shown below in Fig. 3.

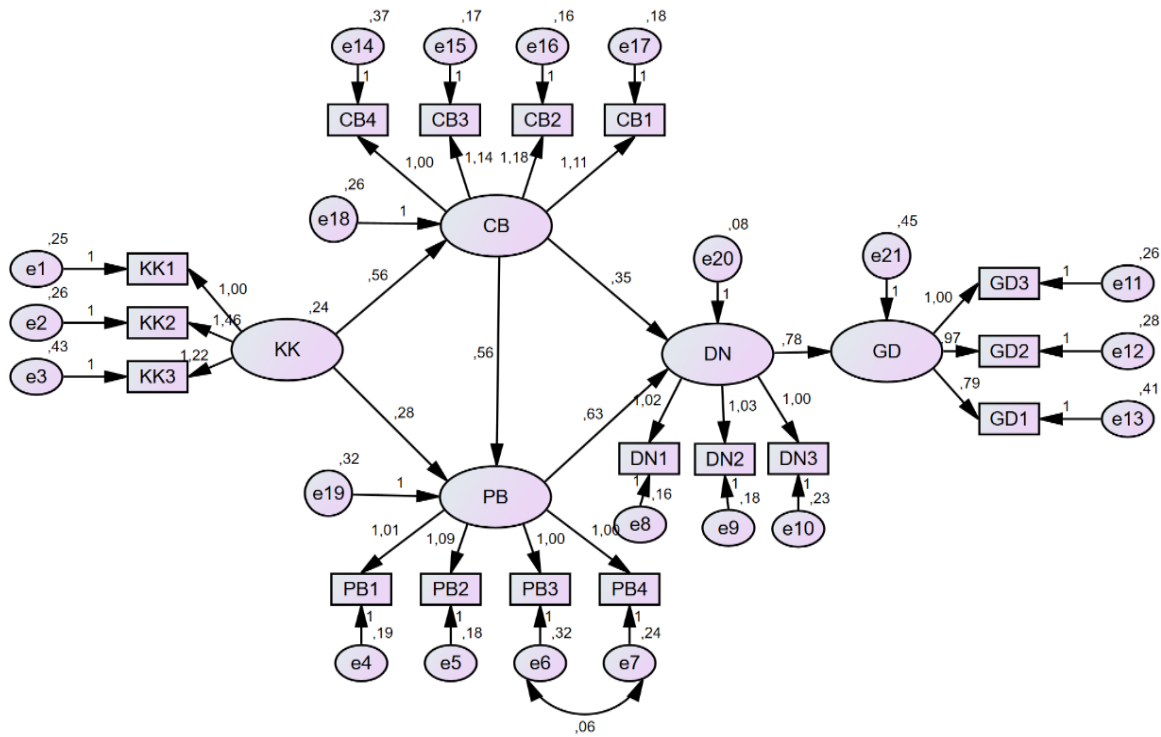


Fig. 3. Structural model. Source: Author’s own illustration on SPSS AMOS.

Several fit indices are considered after Structural Equation Modeling (SEM). The acceptable ranges for these indices and the fit values obtained from the analysis are presented in Table IX.

TABLE IX. MODEL FIT EVALUATION

Fit Index	Ideal Fit	Acceptable Fit	Model Fit
CMIN/DF	$0.00 \leq \text{CMIN/DF} \leq 1.00$	$3.00 \leq \text{CMIN/DF} \leq 5.00$	2.713
CFI	$0.95 \leq \text{CFI} \leq 1.00$	$0.90 \leq \text{CFI} \leq 0.95$	0.960
RMSEA	$0.00 \leq \text{RMSEA} \leq 0.06$	$0.05 \leq \text{RMSEA} \leq 0.6$	0.059
PClose	$0.00 \leq \text{SRMR} \leq 0.05$	$0.05 \leq \text{SRMR} \leq 0.10$	0.038

The results from the Structural Equation Modeling (SEM) analysis are discussed in this section. Model fit indices were found to be  $\text{CMIN/DF} = 2.713$ ,  $\text{CFI} = 0.960$ ,  $\text{RMSEA} = 0.059$ , and  $\text{SRMR} = 0.038$ . Based on the literature, these values indicate that the model has an acceptable and good fit [37], [38]. The CFI and SRMR measurements particularly fall within the ideal fit range, thus proving strong alignment of this particular model with data. An RMSEA measurement that is less than 0.06 means insensitivity to error for this model as well as consistent testing of structural relationships [46].

In view of such results, one may deduce that the formulated structural equation model is congruent with a theoretical framework and fits well with empirical data such that parameters can be interpreted reliably. The fit indices for this model are in agreement with standards from academic literature as well as context-specific adequacy criteria for field studies. Table X below presents standardized regression weights used to assess interactions and relationship strength among factors in the model:

TABLE X. STANDARDIZED REGRESSION WEIGHTS

Factor Relationships	Standardized Regression Weight
Facilitating Conditions → Effort Expectancy	0.475
Facilitating Conditions → Performance Expectancy	0.194
Effort Expectancy → Performance Expectancy	0.464
Effort Expectancy → Behavioral Intention	0.770
Performance Expectancy → Behavioral Intention	0.681
Behavioral Intention → Actual Behavior Use	0.592

Standardized regression weights are coefficients derived from the transformation of variables such that their standard deviations equal one. In other words, these coefficients reveal how many standard deviations the dependent variable will change for a one-standard-deviation increase in the independent variable [47]. Hence, standardized regression weights can be very informative about both the direction and strength of the relationships among variables. Effect sizes are described as small, medium, and large with ranges of 0.10–0.29, 0.30–0.49, and from 0.50 upwards [44]. Looking at Table X, results reveal that Effort Expectancy has a medium effect on Performance Expectancy (= 0.464).

Facilitating Conditions has a weak effect on Performance Expectancy (= 0.194), while it has a medium effect on Effort Expectancy (= 0.475). In addition, Performance Expectancy has a strong effect on Behavioral Intention (= 0.681), and Effort Expectancy has an even stronger effect on Behavioral Intention with = 0.770, indicating that perceived ease of use is decisive in

forming the intention to adopt IPv6 technology. The effect of Behavioral Intention on Actual Use is high with being equal to 0.592. The relationships in the model are mostly at medium and high effect levels with Effort Expectancy and Performance Expectancy being strong determinants of Behavioral Intention, thus proving that the proposed structural model fits theoretical expectations while causal relationships among variables are statistically significant and robust. Moreover, standardized regression weights in this study are consistent with literature, as shown in Fig. 4.

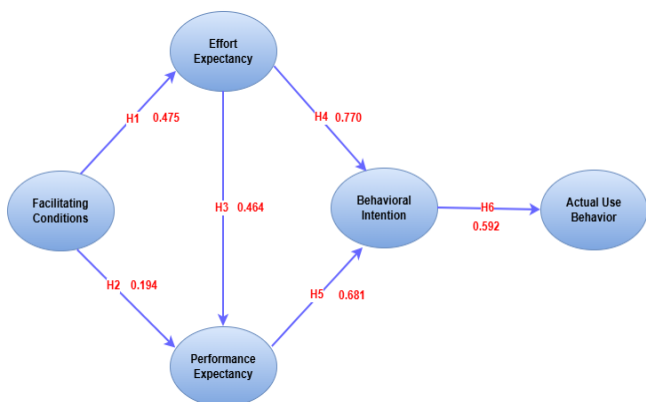


Fig. 4. Standardized regression weights and directions. Source: Author’s own illustration.

The standardized regression weights from the model indicate that the direction and magnitude of the relationships among variables are different. Thus, Effort Expectancy has a medium positive effect on Performance Expectancy ( $\beta = 0.464$ ). This result shows that when learning and using IPv6 technology is perceived as easy, it significantly supports any performance

gains expected from the technology. Facilitating Conditions has a weak effect on Performance Expectancy ( $\beta = 0.194$ ) but, on the other hand, Facilitating Conditions has a medium positive effect on Effort Expectancy ( $\beta = 0.475$ ). This means that existing technical infrastructure and support mechanisms in the organization help in learning and using IPv6 technology. The effect of Performance Expectancy on Behavioral Intention is high and positive ( $\beta = 0.681$ ). In addition, the effect of Effort Expectancy on Behavioral Intention is very high ( $\beta = 0.770$ ). This finding shows that perceived ease of use is a stronger determinant of participants’ intention to use IPv6 technology than performance expectancy. Finally, Behavioral Intention has a high positive effect on Actual Use ( $\beta = 0.592$ ).

Such results that give evidence that good intentions toward IPv6 technology will almost always translate into actual usage behavior. It can be said in general terms that most of the relationships tested in this model have medium to large effect sizes, with Effort Expectancy and Performance Expectancy being significant antecedents to Behavioral Intention. This finding also attests to the fact that the model specified is consistent with the theoretical framework, and all causal relationships among variables are statistically significant and explanatory.

R. Hypothesis Testing

To test the hypotheses formulated in the study, the relationships in the structural model were evaluated. For each path coefficient, the standardized estimate, standard error, critical ratio, and significance level were assessed. Based on these results, decisions were made about whether to accept or reject the hypotheses. This is an approach that determines if the relationships predicted by a model are statistically supported. Results related to these values are given in Table XI.

TABLE XI. EVALUATION OF HYPOTHESES

Hypothesis	Recitations	$\beta$	SE	t (C.R.)	p	Hypothesis Results
H1	Facilitating Conditions → Effort Expectancy	0.560	0.074	7.584	***	Accept
H2	Facilitating Conditions → Performance Expectancy	0.275	0.081	3.381	***	Accept
H3	Effort Expectancy → Performance Expectancy	0.558	0.072	7.746	***	Accept
H4	Effort Expectancy → Behavioral Intention	0.354	0.048	7.296	***	Accept
H5	Performance Expectancy → Behavioral Intention	0.625	0.047	13.234	***	Accept
H6	Behavioral Intention → Actual Use Behavior	0.780	0.069	11.250	***	Accept

\*p<0.001, \*\*p<0.05

S. Hypothesis Testing Results

The significance of relationships among variables in hypothesis testing was determined using Structural Equation Modeling (SEM). Standardized regression coefficients ( $\beta$ ) were used to indicate effectsizes, where values between 0.10 and 0.29 are considered weak, from 0.30 to 0.49 moderate, and above 0.50 strong [48], [49]. Standard error (S.E.) is a measure of the precision of the estimate, while the Critical Ratio (C.R.) is equivalent to a t-statistic, with  $|\text{C.R.}|$  greater than 1.96 indicating statistical significance at  $p < 0.05$ .

As shown in Table XI, the results are statistically significant ( $p < 0.05$ ) [50]. Facilitating Conditions have a strong positive effect on Effort Expectancy ( $\beta = 0.560$ ; C.R. = 7.584;  $p < 0.001$ ,

H1) and a weaker positive effect on Performance Expectancy ( $\beta = 0.275$ ; C.R. = 3.381;  $p < 0.001$ , H2). Effort Expectancy has a strong influence on Performance Expectancy ( $\beta = 0.558$ ; C.R. = 7.746;  $p < 0.001$ , H3) and a moderate effect on Behavioral Intention ( $\beta = 0.354$ ; C.R. = 7.296;  $p < 0.001$ , H4). Performance Expectancy has a strong effect on Behavioral Intention ( $\beta = 0.625$ ; C.R. = 13.234;  $p < 0.001$ , H5), and Behavioral Intention strongly predicts Actual Use ( $\beta = 0.780$ ; C.R. = 11.250;  $p < 0.001$ , H6). These results support the UTAUT model, indicating that Facilitating Conditions influence Effort and Performance Expectancies, which in turn shape Behavioral Intention and lead to the Actual Use of IPv6. The findings emphasize the combined role of individual perceptions and organizational support in achieving high explanatory power.

#### IV. DISCUSSION

The transition to IPv6 should be considered not merely a technical protocol upgrade, but a complex organizational transformation involving behavioral and structural changes in the public sector. Using a modified UTAUT framework, this study examined the integration of IPv6 adoption among IT professionals in the public sector. The empirical findings provide important insights into the socio-technical dynamics of this major digital infrastructure transfer.

##### A. Theoretical Implications

One of the key observations emerging from this study concerns the organizational context in which infrastructure technologies such as IPv6 are implemented. In public sector environments, large-scale technological transitions are typically shaped by institutional strategies, regulatory frameworks, and formal organizational directives. Unlike many voluntary technology adoption settings, the implementation of critical infrastructure technologies often follows structured planning processes and strategic roadmaps defined at organizational or national levels.

In contrast to core UTAUT constructs, social influence was not included in the final model due to its limited relevance in the public-sector context examined in this study. In such environments, technology adoption decisions are predominantly driven by formal mandates, regulatory requirements, and institutional directives rather than peer or interpersonal pressure. Preliminary testing indicated that including social influence did not improve model fit, further supporting its exclusion. This finding suggests that, for large-scale infrastructure transitions such as IPv6, organizational and structural factors outweigh social dynamics in shaping adoption behavior.

In such environments, technology adoption is therefore more strongly associated with institutional capacity and organizational preparedness than with interpersonal dynamics among employees. Professional compliance with institutional mandates often outweighs peer-based influence, suggesting that adoption processes in critical infrastructure contexts are primarily driven by organizational directives and regulatory frameworks rather than by social perception mechanisms typically emphasized in voluntary technology adoption contexts. This perspective highlights the importance of structural and organizational factors in shaping how new infrastructure technologies are perceived and implemented within public institutions.

Another key finding of this study is that Facilitating Conditions (FC) significantly influence both Effort Expectancy (EE) and Performance Expectancy (PE). This result indicates that when IT professionals perceive that their organizations provide sufficient technical resources, training opportunities, and institutional support mechanisms, their beliefs regarding both the ease of use and the expected performance benefits of IPv6 increase substantially. These findings reinforce the socio-technical perspective, suggesting that technological readiness within an organization forms the structural basis upon which psychological acceptance of new technologies develops.

Furthermore, the strong relationship identified between Performance Expectancy and Behavioral Intention demonstrates

that IT professionals evaluate IPv6 adoption primarily through a pragmatic and performance-oriented lens. When the strategic and operational benefits of IPv6—such as scalability, improved network management, and long-term digital sustainability—are clearly understood, individuals exhibit stronger intentions to support and implement the technology.

Taken together, these findings contribute to the limited empirical literature examining IPv6 adoption from an organizational and behavioral perspective. While most previous studies have primarily focused on technical performance or protocol architecture, this study conceptualizes IPv6 migration as a socio-technical transformation process embedded within institutional structures and organizational decision-making environments. In this sense, the study extends technology adoption research by demonstrating how organizational readiness and institutional support mechanisms shape the adoption of large-scale digital infrastructure technologies.

##### B. Managerial and Policy Implications

First, organizations should prioritize institutional readiness. Since facilitating conditions emerge as the primary driver shaping user perceptions, public institutions should invest in structured training programs, dedicated IPv6 laboratories, and robust technical support mechanisms. Reducing perceived complexity through appropriate resource allocation and institutional support is likely to increase both confidence and willingness among IT professionals to engage in IPv6 deployment processes.

Second, management strategies should emphasize the strategic benefits of IPv6 adoption. Internal training and communication initiatives should clearly demonstrate how IPv6 contributes to network scalability, enhanced security capabilities, and long-term digital service sustainability. Framing IPv6 transition solely as a compliance requirement may limit employee engagement, whereas highlighting its operational and strategic value can strengthen behavioral intention.

Third, the findings highlight the importance of clear national-level policy coordination. Since social influence appears to play a limited role in this context, centralized policy directives and coordinated national transition roadmaps remain critical instruments for accelerating IPv6 deployment across public institutions. Government-led digital transformation strategies, therefore, play a decisive role in aligning organizational priorities and ensuring a synchronized transition process.

##### C. Limitations and Future Research

Several limitations should be acknowledged. Despite the relatively large sample size of 456 participants, this study is limited to IT professionals working within the public sector, specifically in state universities in Türkiye. As such, the findings may not fully represent adoption dynamics in private sector organizations or in different national contexts. Future studies could conduct comparative analyses between public and private institutions or across different countries to examine whether the determinants of IPv6 adoption vary across organizational structures and cultural environments.

In addition, the present research relies on cross-sectional self-reported data collected at a single point in time, which may introduce common method bias and potentially inflate the observed relationships among variables. Although this approach is widely used in technology adoption research, future studies are encouraged to employ longitudinal designs or multi-source data to mitigate this limitation and provide a more robust understanding of causal relationships.

Future research may also explore additional organizational variables such as institutional digital maturity, cybersecurity readiness, and regulatory pressure in order to develop a more comprehensive understanding of large-scale digital infrastructure adoption processes.

## V. CONCLUSION

This study examined IPv6 adoption in public institutions using a modified UTAUT framework. The findings show that performance expectancy, effort expectancy, and facilitating conditions significantly influence behavioral intention, which in turn strongly predicts actual use. The results indicate that IPv6 adoption in the public sector is primarily driven by organizational capacity, institutional support, and policy-oriented processes.

From a practical perspective, strengthening institutional infrastructure, providing technical support, and improving user readiness are critical for successful IPv6 implementation. The study contributes to the literature by extending UTAUT to a public-sector infrastructure context.

Future research may conduct cross-sector comparisons and employ longitudinal designs to further examine how adoption dynamics evolve over time.

## DECLARATIONS AND DISCLOSURES

- **Ethical Responsibilities of Authors:** The authors declare that they have complied with the principles of research and publication ethics.
- **Ethical Approval:** Ethical approval for this study was obtained from the Atatürk University Social and Human Sciences Ethics Committee (Ref: E.88656144-000-2500036446, Session No: 3, Decision No: 44, Date: 31.01.2025).
- **Conflicts of Interest:** The authors declare that there is no conflict of interest regarding the publication of this study.
- **Funding:** This research received no external funding.
- **Author Contributions:** Conceptualization and study design: Aydın Koçak; methodology development and manuscript drafting: Aydın Koçak; writing, language editing, and methodological refinement: Uğur Dağtekin; data analysis and interpretation: Ahmet Kamil Kabakuş. All authors have read and approved the final version of the manuscript and accept full responsibility for its content.
- **Use of Generative AI:** AI tools were used only for minor language editing and surface-level textual improvements. They were not used in the research

design, data analysis, or interpretation of findings. All academic content and conclusions are the sole responsibility of the authors.

- **Plagiarism Statement:** This manuscript was screened for potential plagiarism using appropriate plagiarism detection software.
- **Additional Disclosure:** This study was derived from the first author's doctoral dissertation conducted in the Department of Management Information Systems at Atatürk University.

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