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**„MÉRLEG ÉS KIHÍVÁSOK –
ÉRTÉKTEREMTÉS-FENNTARTHATÓSÁG-
DIGITALIZÁCIÓ”**

**XIII. NEMZETKÖZI TUDOMÁNYOS KONFERENCIA
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A COMPREHENSIVE EVALUATION OF THE GRADUAL TRANSFORMATION AND DEVELOPMENT OF TECHNOLOGY ACCEPTANCE MODELS

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ABSTRACT

The study of technology acceptance is essential in understanding how and why individuals adopt new technologies and innovations. As communities increasingly rely on technological solutions for a great array of everyday challenges, it becomes crucial to explore the factors that influence the acceptance and integration of these innovations. Investigating the underlying dynamics of technology adoption offers invaluable insights to developers, policymakers and stakeholders, providing guidance to design, implement and promote technologies that reflect user needs and societal expectations.

The pillars of the technology acceptance theories and constructs can be traced back to various models, including the Technology Acceptance Model (TAM), which introduced key concepts such as perceived ease of use and perceived usefulness. Over time the TAM evolved, incorporating additional variables to better capture the complexity of human behaviour in response to technology. The Unified Theory of Acceptance and Use of Technology (UTAUT) emerged as a prominent model, integrating several previous approaches and expanding the theoretical landscape by introducing new constructs like social influence.

This paper attempts to review the evolution of technology acceptance models, with a particular focus on the change of their conceptual and theoretical foundations. Through a comprehensive literature review, the study examines key concepts, variables and the integration of related theories such as the Theory of Planned Behavior (TPB) and some other alternative approaches. Finally, a critical evaluation of UTAUT and its alternatives is presented addressing the most recent academic concerns too. The findings of this review emphasize the importance of the constant refining of technology acceptance models to keep pace with the rapid advancement of technological innovations and the ever-changing user expectations.

1. INTRODUCTION

In recent years, it has become increasingly apparent that technological innovations have been evolving regardless of the actual demand and competencies of the population. These innovations no longer correspond to the real market trends and there is a lack of clear reflection of existing societal needs [21]. As a matter of fact, recent innovations can be considered as the culmination of the continuous development of previous innovations. These tendencies necessarily cause a certain tension within the society, which effects the general acceptance of the technologies and hence their market success [32].

A certain part of these innovations is often referred to as disruptive technologies. The term itself was created by Clayton M. Christensen in 1997 in his seminal work ‘The Innovator’s Dilemma’ [20]. The disruptive nature of these innovations lies in their potential to displace established technologies, generating significant shifts in the market and in the industry [53, 18]. Disruptive technologies are likely to appear in niche markets and by continuous development and adaptation they are imposing a strong challenge to mainstream products [26]. This specific potential is justified by their ability to increase the effectiveness of production and decrease the operating costs of economic organisations [62].

The time needed for the completion of the innovation process has been substantially reduced [46], which means that the amount of new technologies the public must familiarize with has widened, ensuring much less time and possibility for consumers to acclimate to these new solutions. In other words, the technological sophistication of the newly introduced innovations frequently exceed the technological sophistication of the people who are meant to use them [24], leading to uncertainty about their true potential.

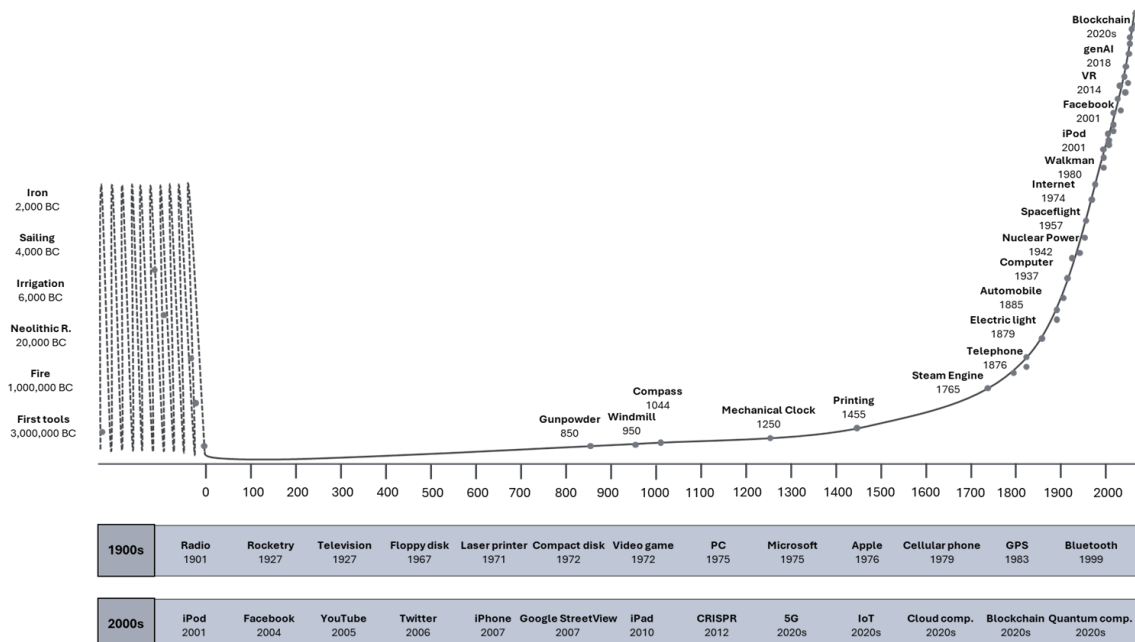


Fig. 1.: A chronological overview of technological innovations
Own edition based on [13, 23]

Putting emphasis on acceptance and explicitly investigating the behavioural intentions and other crucial factors that influence the adoption of emerging technologies allows us to narrow the gap between novel technological solutions and consumer needs and competencies [38], anchoring the means of development to reasonable grounds by helping businesses and other decision making institutions to develop effective strategies and plans to promote the successful attainment of technological adoption [10, 11]. Ultimately, the potential efficacy of these innovations and the persistent economic drive of companies to increase profitability can only be realised if we are able to find a common ground with the consumers and overcome the barrier of acceptance. On condition that we identify and systematically address the factors that lead to resistance, developers and policymakers can design and implement technologies that are more likely to be accepted and used effectively by the consumers, thereby minimizing the chance of rejection and enhancing user satisfaction [27, 50]. The case of three-dimensional television serves as an appropriate example for this particular phenomenon, as the rapid decline of this technology was subsequently attributed to consumers' perceptions of it being too circumstantial, which hindered its widespread adoption [25]. Technology acceptance models can therefore be of great help prior to the introduction of new products to the market, as a matter of fact, this would (or should) be the primary goal of the theory.

Another aspect in which technological acceptance studies have proven to be useful is the cultural and contextual differentiation of the existing knowledge. As technology acceptance studies are always situational and consider cultural influences, they can provide accurate and tangible recommendations for the planning of implementation strategies, ensuring that the

offered technological solutions are in line with the unique needs and preferences of the different consumer segments [28, 50].

Based on the previously discussed sections, it can be concluded that in the 21st century, it is more important than ever to analyse and comprehend the factors that contribute to the acceptance of technological innovations and to identify those aspects that determine whether people will be willing to modify their established habits or use behaviour. In the forthcoming parts of this paper, I will provide an overview of the most important models that have aimed to understand the technology acceptance of consumers, and I will attempt to explain the general evolution of these theories. Additionally, I will discuss the key concepts relating to this field, while also presenting a critical evaluation of the various approaches. In the final part, I will elaborate on the primary means for further development of the UTAUT model.

2. THEORETICAL FOUNDATIONS AND THE EVOLUTION OF TECHNOLOGY ACCEPTANCE MODELING

The primary focus of technology acceptance theories and models is to convey the concept of how consumers may perceive, accept and utilize a particular technology. These theories aim to identify the key variables that influence the decision-making process of individuals and their willingness to adopt and use a given technology [37]. The appearance of technology acceptance models played a crucial role in the evaluation of consumer perceptions of innovations, allowing researchers to identify their shortcomings and setbacks [42]. Consequently, it is of great importance to overview the history of technology acceptance modelling in order to assess its chronological development and evolution, identifying the ways in which the different approaches show resemblance or incorporate certain aspects from one another. This paper aims to provide a critical overview of the most significant and widely used theories of technology acceptance as follows. The earliest technology acceptance theory is the Theory of Reasoned Action (TRA) [3], which later evolved into the Theory of Planned Behavior (TPB) [1]. The spread of computing technologies in the mid-1980s necessitated the more direct and exact evaluation of the factors that determine the acceptance of this revolutionary technology [30] which resulted in the appearance of the Technology Acceptance Model (TAM) [14]. This model strongly builds upon the TRA and has three extensions, namely the TAM2 [58] and TAM3 [57]. The combination of the TAM and the TPB resulted in the creation of the C-TAM-TPB model [49]. Other significant models include the Self-Determination Theory (SDT) [16], the Model of PC Utilization (MPCU) [51], the Innovation Diffusion Theory (IDT) [45] and the Social Cognitive Theory (SCT) [9]. The integration of these eight key modelling approaches finally resulted in the creation of the Unified Theory of Acceptance and Use of Technology (UTAUT) [55]. Finally UTAUT2 [56], an improved version of the UTAUT model is considered to be the most sophisticated method for the quantification and modelling of consumer technology acceptance, providing a relatively accurate and differentiated picture of the factors that play a crucial role in the success of innovations.

The aforementioned approaches are all designed to measure the degree of acceptance and perception of individuals towards any technology. The difference between them can be traced back to their viewpoints and the system of constructs and determinants they incorporate to their framework [37]. In the followings, I will provide an overview of the key aspects of these theories, with particular emphasis on their limitations.

The Theory of Reasoned Action (TRA) is a socio-psychological model developed by Martin Fishbein and Icek Ajzen in 1967 and it is considered to be the earliest technology acceptance theory. The core component of the TRA is *behavioural intention*, which represents an individual's intention to engage in a particular activity, thereby serving as a direct predictor of

consumer behaviour [43]. An important aspect of this theory is that it puts great emphasis on the role *attitude* (i.e. the individual's positive or negative evaluation of performing the behaviour) plays as an influencing factor. Additionally, the TRA identifies *subjective norms* as equally crucial variables that shape behavioural intentions. TRA employs a belief-based framework to explain these relationships and has been adapted to a variety of contexts since its development [36, 39]. For all that, TRA is a general model of social psychology aimed at the explanation of consumer behaviour, it was not designed specifically to analyse an exact behavioural context or a technology [37]. Furthermore, some researchers argue that the rather narrow and simplified use of variables result in insufficient predictive power [19].

The Theory of Planned Behaviour (TPB) can be identified as an extension of the TRA developed by Ajzen [1]. TPB is a robust model for predicting behaviour, which (in addition to attitude and subjective norms) introduces a new variable, i.e. *perceived behavioural control* (PBC). Perceived behavioural control can be defined as an individual's perception in connection with the ease or difficulty of performing an certain behaviour [6]. The Theory of Planned Behavior has been extensively employed across diverse domains, encompassing information systems, online learning, information security, physical activity and clinical trial participation [22, 44]. Some limitations of the model include the inconsistent conceptualization of certain determinants, such as perceived behavioural control, and the necessity to consider temporal changes in both intentions and behaviours [7]. Additionally, the model also displays a rather simplified explanation of consumer behaviour, ignoring important psychological factors of consumers like fear, mood and past experience or other circumstantial determinants such as environmental or economic variables that may as well play a crucial role in influencing an individual's intention to perform a behaviour [52].

The first widely used technology acceptance model was developed by Davis 1989 (i.e. Technology Acceptance Model, TAM). This model is the pioneer theory that centres on the consumer acceptance process of emerging technologies in the 20th century. Its significance can be underpinned by the fact that the TAM model served as a theoretical foundation for numerous other technological models [30]. In this model, the *actual use* (the output variable of the construct) is preceded by the *intention to use*, which is influenced by the *attitudes* relating to the use behaviour. According to the model, the individual's attitude is determined directly by two mediator variables, i.e. *perceived ease of use* and *perceived usefulness*, and indirectly by some non-specified *external factors*. Perceived usefulness measures how much consumers and participants believe a technology benefits them, such as improving efficiency, increasing performance, or enhancing quality of life. Perceived ease of use assesses the mental and physical effort required to use the technology.

The second version of the TAM model (TAM2) developed by Venkatesh and Davis (2000) takes a more differentiated approach to the external factors, and also includes two moderating variables (*experience* and *volunteering*) that influence the relationships between the model's constructs. The *subjective norm* represents a type of social influence, as it examines how an individual's personal values are affected by the opinions and approval of significant others regarding the technology in question. The concept of *image*, or self-image, is closely tied to subjective norms, given that individuals often respond to external social pressures in order to create or maintain a desired, favourable perception of themselves within a particular reference group. The external variables outlined in the TAM2 model are only in direct relation with the perceived usefulness variable.

The most complex Technology Acceptance Model (TAM3) encompassing the most influential factors was developed by Venkatesh and Bala (2008). In their proposed model, they further expanded the range of external variables to include additional factors such as *technical self-efficacy*, *perceived external control*, *technology anxiety*, the *playfulness of technology*, the

perceived enjoyment, and the *objective usability*. These factors are classified into two groups. One group, the *behavioural anchors*, influences the individual's opinion before personal experience with the technology. The other group (i.e. *adjustments*) consists of correction factors that shape the consumer's opinion after direct experience. A range of these new, external factors are directly associated with perceived ease of use.

Different versions of the Technology Acceptance Model have been extensively employed across a wide array of research domains. The primary objections and criticisms levelled against TAM pertain to its inherent limitations, as it primarily examines two constructs: perceived ease of use and perceived usefulness. This narrow focus is insufficient to comprehensively capture the complex dynamics underlying technology acceptance, as it excludes several crucial factors such as integration and flexibility (for example the first version treats external variable homogeneously) [34]. Furthermore, the model fails to address consumer expectations regarding technology as well as assessing the respondents comprehension about the complexity of the technology [33]. Finally, TAM does not adequately address the cultural differences between the respondents, which can have a serious impact on the acceptance of technology for instance in multicultural environments [6].

The Combined Technology Acceptance Model and Theory of Planned Behaviour (C-TAM-TPB) is an integrated framework that merges the elements of the TPB and TAM with the aim of providing a better explanation for consumer behaviour and predicting user acceptance with respect to a certain technology. The C-TAM-TPB (developed by Taylor & Todd, 1995) offers a solution for some of the limitations explained in the previous paragraphs, namely it brings a more technically relevant view to the general behavioural model of TPB, meanwhile expanding the TAM with more diverse individual factors as attitude and subjective norms [12]. Although the model improved in some aspects compared to its predecessors, the most crucial criticism, the lack of adequate differentiation and variable count is still not overruled [5].

Self-Determination Theory (SDT) emerged as a new line of motivational research developed by Deci & Ryan (1985). The key concept of their theory is choice, i.e. the personal experience of having and making choices, which constitutes a significant human quality: self-determination. This motivational approach to the study of behaviour created a new dimension to the general explanation and analysis of consumers' decision-making processes. In one of their later studies [17] the researchers proved that consumer behaviour depends on the regulatory process of a situation. Provided that the consumers interact in a choice-based environment self-determination will be the key aspect of their behaviour, on the other hand, if there is a controlled regulatory process, the behaviour could alter to compliance, or in some cases, defiance too. Although the model proves to be useful in the modelling of human behaviour, it fails to adequately address technological aspects and factors determining the use of technology and there is a need for the further adjustment of the framework with a differentiative view on the variables [54].

The Model of PC Utilization (MPCU) is a conceptual construct that aims to predict and explain the various determinants of the use and acceptance of personal computers and other relating technologies. The MPCU concept was created by Triandis (1979), who studied the behavioural aspects of PC usage from a cause-and-effect perspective. The MPCU provides an individually more relevant approach to the study of technology acceptance, as the model highlights a humanistic dimension (underpinning consequence interpretation and reinforcement affects) rather than focusing on mere organizational factors [15]. As for the limitations of the model, one could raise the criticism of the lack of a sophistication with regard to the framework constructs and socio-psychologically relevant variables.

Innovation Diffusion Theory (IDT) is a concept developed by Everett Rogers in 1983. The theory provides valuable insights into the spread of innovations in different social systems as

well as the factors that determine the course of diffusion. The IDT identifies four key components of the diffusion process, i.e. (1) innovation: the new idea, technology or solution being introduced; (2) communication channels: the means by which the news about the innovation can be transmitted; (3) time: the period over which the innovation is adopted and (4) social system: the group of entities that are adopting the innovation [60]. According to Rogers (1983), the adoption process in the case of innovations has the shape of an S-curve, representing a cumulative number of adopters over time. In the beginning – at the time of introduction – there is a slow rate of adoption, which is later followed by a rapid acceleration, and finally, as the market approaches its maximum capacity, the curve shows a stagnation, a so-called plateau. The adoption process can be segmented into five parts. The first part is labelled as ‘knowledge’, as this is when consumers are starting to familiarise themselves with the innovation, awareness is being raised about the new solution. It is then followed by the stage of ‘persuasion’ where the innovation has to receive a general interest and a positive evaluation. Following that, the consumers have to make a ‘decision’ to adapt or to reject the innovation. The process of innovation diffusion doesn’t stop here as consumers have to decide upon the actual use of the innovation (‘implementation’) and then reinforce their decision to adopt (‘confirmation’) [29]. IDT identifies five factors that determine five critical variables that determine the adoption of innovations, these are *relative advantage* (the perceived improvement over already existing solutions), *compatibility* (consistency with existing conditions), *complexity* (difficulty of understanding and usage), *trialability* (the limits of testing the innovation) and *observability* (how visible the benefits of the innovation are to others) [40]. Although this model successfully manages to explain the adoption process of innovations, but it fails to address the role individual attitudes play in the acceptance or rejection of innovations, or how the different social backgrounds affect the adoptions [37].

Social Cognitive Theory (SCT) is one of the most influential conceptual frameworks explaining human behaviour. The theory proposes that behaviour is shaped by the complex, dynamic relationship between individual attributes (e.g.: knowledge, expectations, attitudes), environmental factors (e.g.: social norms), and the behaviour itself (e.g.: self-efficacy, practice), a concept known as reciprocal determinism [61]. The origins of the concept are dated back to the 1940s, when the Social Learning Theory (SLT) was formulated by Miller & Dollard with the aim of modelling the principle of learning. It was Bandura (1986) who later transformed the SLT and proposed the SCT model as a compelling alternative. One of the biggest strengths of the theory is that it provides a rather versatile approach to the understanding of human behaviour by integrating both cognitive, behavioural and environmental factors to its framework. Additionally, the model also proves to be quite promising with regard to its predictive abilities [8]. On the other hand, the individual focus limits the scope of the effects, excluding the relational dynamics of the consumers in such behavioural cases where interaction plays a part too (for example parent-child interactions) [61].

The Unified Theory of Acceptance and Use of Technology was developed by integrating and refining eight preceding models and theories [55]. Similar to the Technology Acceptance Model, the UTAUT framework focuses on consumers' actual usage and intention to use a particular technology, as well as the independent and moderating factors that influence these key variables. The interpretation of the external determinants in the UTAUT model largely aligns with the TAM approach. However, the enhanced UTAUT 2 model also examines indicators pertinent to new technological innovations intended for general consumer use, such as *hedonistic motivation* (the degree of pleasure and entertainment provided by the use of technology), *price value*, and *habits* (previous use of similar technologies) [56].

The critical evaluation of the UTAUT alternatives will be discussed in the final chapter of this paper along with the elaboration of their means for further development.

As a conclusion, it can be established that the study of technology acceptance is situated within the field of behavioural sciences and has evolved concurrently with the technological advancements of the previous century. This research area has aimed to model the factors that influence the acceptance of technology through increasingly complex systems. Building upon each other, these models – which analyse the behaviour of consumers from psychological, motivational, social and other aspects – have continuously refined the available knowledge, and by integrating various theories, they have developed the UTAUT model and its extension, the UTAUT 2, which represents the most sophisticated and current validated methodology for analysing technology acceptance.

3. RELATING THEORIES AND MODELLING APPROACHES

In addition to the models and theories previously discussed, consumers' acceptance of technology is further elucidated by the Value-based Adoption Model and the Behavioural Reasoning Theory [2, 31]. These two approaches share a common focus on examining consumer values and value systems, and how they influence the process of technology acceptance.

4. CRITICAL EVALUATION OF UTAUT AND MEANS FOR FURTHER DEVELOPMENT

Despite the UTAUT model being the most suitable theoretical framework for understanding technology acceptance as of today, there are still some reservations about the theory, its predictive power and generalisability. This section will outline the key academic proposals and expectations for the further development of the UTAUT models.

Incorporating additional constructs like Self-Efficacy, Trust, and Personal Innovativeness can enhance the UTAUT2 model's capacity to explain technology acceptance in educational contexts, according to recent studies [35, 47].

Customizing the UTAUT2 framework to particular contexts, such as mobile phone utilization in academic libraries or AI applications in higher education, can yield more precise forecasts of behavioural intentions [41]. For example, in the context of mobile library services, factors like self-efficacy and trust were identified as significant determinants [41].

Emphasizing the core determinants of Performance Expectancy, Effort Expectancy, and Social Influence, which have been consistently shown to significantly impact behavioural intention, can help streamline the UTAUT2 model for practical applications. Among these, Performance Expectancy has been identified as a particularly critical factor across various studies [4, 56].

Identifying and addressing barriers such as mistrust and insufficient knowledge, while capitalizing on facilitators like prior technological experience and technological self-efficacy, can enhance the model's real-world applicability and effectiveness [48].

In their latest work Venkatesh et al., 2016 synthesised the researches (published between 2003-2014) that integrated the UTAUT models, performing a theoretical analysis of the applications and their extensions. Their results show that the original UTAUT models have received criticism mostly relating to their limited ability to support the development of theories, as they are constrained by rigid and well-defined constructs. The exclusion of meso- or macro-level factors can be identified as another limitation of the model, which leads to an overemphasis of the individual-level determinants of technology acceptance and use. This narrow focus restricts the model's applicability to broader contexts, either organisational or societal. Furthermore, critics argue that the original UTAUT model is overly frugal and simplifying, concentrating on a limited set of variables, such as performance expectancy, effort expectancy, social influence, and facilitating conditions, without considering other external factors or levels of analysis. In

response, the article proposes a *multi-level framework* that aims to address these criticism by incorporating context-driven factors and cross-context theorizing. This multi-level framework combines micro (individual) and macro (organisational, cultural, group) components to provide a more holistic understanding of technology acceptance. Additionally, the proposed framework urges researchers to investigate not only individual-level technology adoption, but also how organizational structures, cultural environments, and external factors influence technology utilization. The framework aims to bridge the gap between the original UTAUT's strengths and the need for a broader, context-sensitive approach that can account for varying levels of analysis. This novel approach facilitates more detailed researches into technology acceptance, offering a more flexible and adaptable model for diverse contexts, such as consumer settings, government, and healthcare sectors.

Key alterations proposed include:

- Expanding beyond individual-level constructs by integrating organizational and cultural factors.
- Applying cross-context theorizing to understand how context affects technology use.
- Encouraging multi-level studies that examine interactions between individuals and their surrounding environments (e.g., organizational norms, societal values).

To conclude, while the original UTAUT model has been highly influential, the proposed alterations and multi-level framework aim to enhance its scope and adaptability by addressing its theoretical and practical limitations.

5. SUMMARY

This paper demonstrated the need for the thorough analysis of technology acceptance and reviewed the evolution of the relating models and theories, as well as their interconnectedness and methodological approaches with a critical view. TAM, developed by Davis (1986), introduced perceived ease of use and perceived usefulness as core determinants of technology adoption, but was critiqued for its narrow focus. The evolution of TAM into TAM2 and TAM3 introduced additional factors like social influence and perceived enjoyment, yet still faced criticism for excluding broader contextual variables. UTAUT, which integrated multiple models, expanded the theoretical framework but also received criticism for focusing too much on individual-level factors. A multi-level framework is proposed by Venkatesh et al. (2016) to address these limitations by incorporating organizational, social, and cultural contexts. The proposed model emphasizes the need for cross-context theorizing and the integration of macro-level factors to better predict technology acceptance across various environments. This research highlights the need for future studies to move beyond individual constructs and include broader contextual influences for a more comprehensive understanding of technology acceptance.

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