NAVIGATING THE DIGITAL LANDSCAPE WITH A COMPREHENSIVE REVIEW: CHALLENGES AND LIMITATIONS OF THE TECHNOLOGY ACCEPTANCE MODEL*

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Abstract

This article aims to conduct an in-depth analysis of the Technology Acceptance Model (TAM), elucidating its developmental trajectory, foundational principles, subsequent modifications, and current applications in diverse sectors. By doing so, it seeks to understand the evolving dynamics of technology adoption and address the critiques of TAM's limitations. The core of this article revolves around the Technology Acceptance Model, exploring its origins, theoretical underpinnings, and various enhancements over the years. The review synthesizes past research, highlights extensions like TAM2 and UTAUT, and discusses their implications in the context of rapid technological change and cultural variability. Key to this discussion is the role of perceived usefulness and ease of use as primary drivers of technology adoption, supplemented by newer constructs in updated models. The findings of this comprehensive review are crucial for academics, practitioners, and policymakers. Academically, they enrich the literature on technology acceptance by providing a historical overview and a

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critique of TAM's adaptability to modern needs. Practically, insights from this review can guide the development of more user-centric technologies and organizational strategies that foster technology acceptance. Policy-wise, understanding the nuances of TAM can help in formulating more effective technology adoption frameworks that are culturally and contextually appropriate. This article contributes to the literature by offering a consolidated review of TAM and its evolutions, critiquing its efficacy and relevance in contemporary technology environments. It uniquely addresses the cultural and emotional dimensions often overlooked in traditional models, providing a pathway for future research to integrate these aspects into technology acceptance studies.

Keywords: Technology Acceptance Model, Technology Adoption, Technology Usage

Introduction

The expeditious progression of technological innovations has fundamentally transformed the operational dynamics of enterprises and the interpersonal engagements of individuals (El-Haddad & Al-Shammari, 2023). The comprehension of the elements that contribute to the acceptance and adoption of emerging technologies is of utmost importance as they progressively integrate into various aspects of life and business (Kamkankaew et.al., 2022). The Technology Acceptance Model (TAM) is a widely recognised paradigm that is used to investigate and understand the factors that influence the acceptance and usage of technology (Davis, Bagozzi, & Warshaw, 1989; Hwang & Shin, 2022).

Davis first introduced the Technology Acceptance Model (TAM) in the late 1980s as a theoretical framework for predicting the adoption of information systems. This model identifies two fundamental factors that play a significant role in determining acceptance: perceived usefulness (PU) and perceived ease of

use (PEOU) (Davis, 1989). According to the Technology Acceptance Model (TAM), the likelihood of consumers adopting and utilising a technology is influenced by their perception of its potential benefits for their work (perceived usefulness, PU) and their perception of its perceived ease of use (PEOU) (Davis, 1989). Throughout its existence, the Technology Acceptance Model (TAM) has experienced numerous expansions and alterations, resulting in a more encompassing and flexible framework that can effectively accommodate evolving technology environments (Venkatesh & Davis, 2000; Venkatesh, Morris, Davis, & Davis, 2003).

The extensive applicability of TAM is evidenced by its utilisation in diverse domains, including but not limited to health care, education, e-commerce, and mobile apps (Holden & Karsh, 2010; Teo, 2009). The aforementioned model has demonstrated its durability and straightforwardness, enabling accurate predictions of technology adoption in diverse contexts, thereby establishing its enduring validity (Kaur & Kaur, 2022). One significant advantage of the Technology Acceptance Model (TAM) is its inherent versatility (Kamkankaew et.al, 2023a). The model has been enhanced by researchers through the inclusion of external components, such as social impact and conducive situations, in order to increase its contextual specificity (Venkatesh et al., 2003; Ismagilova & Dwivedi, 2020; Khan, Khan & Khan, 2021; Mahapatra & Jena, 2023). The fundamental principles of the Technology Acceptance Model (TAM), namely perceived usefulness and perceived ease of use, continue to serve as fundamental components in comprehending the acceptance of technology (Venkatesh & Davis, 2000).

The importance of the Technology Acceptance Model (TAM) in both academic and business contexts cannot be overemphasized enough. Organisations have the opportunity to utilise the knowledge gained from the Technology Acceptance Model (TAM) in order to develop interventions and strategies that promote the acceptance of technology among end-users. This, in turn, can contribute to the successful implementation of systems (Venkatesh &

Davis, 2000; Hwang & Shin, 2022). Organisations can enhance resource allocation efficiency and facilitate easier transitions during technological shifts by conducting an analysis of the barriers and facilitators of technology uptake (Lee, Kozar, & Larsen, 2003). Moreover, in light of the increasing necessity of digital transformation in the corporate landscape, gaining insights into user behaviour through frameworks such as the Technology Acceptance Model (TAM) confers a significant strategic advantage in the contemporary digital era. Hence, the Technology Acceptance Model (TAM) provides a comprehensive comprehension of the cognitive and affective elements that influence the adoption and utilisation of technology (Venkatesh & Davis, 2000; Venkatesh, Morris, Davis, & Davis, 2003). The model's fundamental position within the realm of technology acceptance studies is highlighted by its lasting significance in both academic research and practical applications (Abdullatif & Sulaiman, 2022; El-Haddad & Al-Shammari, 2023).

The primary objective of this extensive review article is to provide an in-depth analysis of the Technology Acceptance Model (TAM), which is considered a fundamental framework for comprehending the acceptance and utilisation of technology. Throughout its existence, the Technology Acceptance Model (TAM) has demonstrated its significance in various settings. However, it has encountered obstacles, faced criticism, and consequently undergone revisions. This article aims to shed light on these aspects, with a specific focus on the inherent issues of the paradigm, the adjustments it has experienced, its acknowledged limitations, and the criticisms it has received from both the academic and practitioner worlds. This review aims to offer scholars and practitioners a comprehensive comprehension of the growth of TAM and its relevance in the current, swiftly changing technological environment.This review article provides a comprehensive overview of the Technology Acceptance Model (TAM), encompassing its historical development, identified challenges, limitations, of

technology acceptance model (TAM), as well as its potential impacts and future research opportunities.

A Short Historical Context of Technology Acceptance Model (TAM)

The rapid growth of technological advancements during the latter portion of the 20th century necessitated a comprehensive comprehension of the ways in which individuals acclimatise to and embrace novel technologies (El-Haddad & Al-Shammari, 2023). This part prompted researchers to explore frameworks and models that may forecast the adoption and behaviour of technology usage. The emergence of the Technology Acceptance Model (TAM) occurred within this context, serving as a notable theoretical contribution.

Origin of TAM

Fred Davis initially created the Technology Acceptance Model (TAM) in the late 1980s (Davis, 1986). Davis (1986) conducted research during his doctoral studies at the Massachusetts Institute of Technology with the aim of identifying the various factors that influence the acceptability of technology, particularly in relation to computer technology. Based on the Theory of Reasoned Action (TRA), a psychological theory developed by Ajzen and Fishbein (1977) to explain the connection between attitudes, intentions, and behaviour, Davis constructed the Technology Acceptance Model (TAM) as a framework designed specifically to examine the acceptance of technology.

The Technology Acceptance Model (TAM) introduced two fundamental notions, namely perceived usefulness (PU) and perceived ease of use (PEOU). According to Davis (1989), the influence on an individual's behavioural intention to use a technology, as well as their subsequent actual usage of the technology, may be attributed directly to these two perspectives. The concept of perceived utility was operationalized as the degree to which an individual holds the belief that utilising a particular technology would result in improved job performance.

On the other hand, perceived ease of use was conceptualised as the extent to which an individual holds the belief that utilising a particular technology would require minimal effort.

The Davis study produced a model that was both robust and frugal, demonstrating significant empirical efficacy in forecasting user acceptance and technology adoption in various scenarios. The study conducted by Davis, Bagozzi, and Warshaw (1989) provided validation for the Technology Acceptance Model (TAM) and emphasised its effectiveness in predicting user behaviour towards technology.

Evolution of TAM over the Years

Throughout its existence, the Technology Acceptance Model (TAM) has experienced numerous iterations and extensions. Critical analysis and the need to adapt to the constantly changing technological environment have both driven these changes.

The introduction of TAM2 by Venkatesh and Davis (2000) aimed to expand upon the original Technology Acceptance Model (TAM) by incorporating supplementary theoretical constructs that could potentially impact perceived usefulness. These constructs include social influence processes, such as subjective norm and voluntariness, as well as cognitive instrumental processes, such as job relevance, output quality, and result demonstrability.

Venkatesh et al. (2003) put forth the Unified Theory of Acceptance and Use of Technology (UTAUT), acknowledging the intricate nature of technology adoption. The UTAUT framework incorporates components from other influential models, such as TAM and TAM2, in order to present a comprehensive structure that identifies four primary factors influencing the intention and behaviour of usage. These factors include performance expectancy, effort expectancy, social impact, and facilitating conditions.

Venkatesh, Thong, and Xu (2012) subsequently proposed the UTAUT2 model, which expanded upon the UTAUT framework by incorporating the

consumer context. The aforementioned model introduced three more components, namely hedonic motivation, price value, and habit, thereby emphasising the wider spectrum of factors that impact the adoption of technology in a consumer context.

The Technology Acceptance Model (TAM) and its succeeding revisions have played a significant role in the field of technology adoption. However, it is important to acknowledge the critiques that have been directed at it. Benbasat and Barki (2007) contend that the model lacks complexity since it fails to consider the multitude of external factors that can influence the adoption of technology. Nevertheless, the simplicity of the technology has frequently been praised as a notable advantage, since it enables easy integration into many technical environments. The Technology Acceptance Model (TAM) has undergone ongoing development in recent years as scholars have expanded and enhanced the model to incorporate novel technology and developing patterns. The incorporation of novel constructs, such as hedonic incentives, perceived privacy risks, and perceived security risks, these constructs are indicative of the growing trend among individuals to utilise technologies for both recreational and social objectives while simultaneously expressing apprehension regarding the safeguarding of their personal information and ensuring its confidentiality.

The emergence of novel variations of the Technology Acceptance Model (TAM), such as the Unified Theory of Acceptance and Use of Technology (UTAUT) and the Mobile Acceptance Model (MAM), has contributed to the advancement of this field. These variants encompass supplementary variables and elements that are pertinent to the adoption and utilisation of particular categories of technology, such as mobile phones and social media. The utilisation of the Technology Acceptance Model (TAM) in novel settings, such as healthcare, education, and government sectors, this observation underscores the increasing significance of technology within various industries.

Numerous studies conducted between 2020 and 2023 have provided evidence regarding the efficacy of the Technology Acceptance Model (TAM) in forecasting the acceptance and utilisation of diverse technologies across various contexts. The study conducted by Al-Ansi et al. (2020) demonstrated that the Technology Acceptance Model (TAM) proved to be a dependable indicator for predicting the acceptance and utilisation of e-learning platforms amidst the COVID-19 pandemic. The research emphasised the substantial direct influence of perceived usefulness and perceived ease of use on users' attitudes towards these platforms, subsequently affecting their intention to utilise them. In a similar vein, the study conducted by Al-Smadi et al. (2021) demonstrated the relevance of the Technology Acceptance Model (TAM) in the context of telemedicine service adoption. The researchers identified that users' attitudes and intention to use were significantly influenced by their perceptions of the usefulness and simplicity of use associated with the technology. The study conducted by Al-Shammari et al. (2022) expanded the scope of TAM's applicability to include social media platforms in the context of education. The findings of the study revealed that TAM successfully predicted user acceptance, with perceived utility and perceived ease of use continuing to influence attitudes and intentions. In a recent study conducted by Al-Khaldi et al. (2023), the researchers provided more support for the applicability of the Technology Acceptance Model (TAM) framework. This particular investigation focused on the domain of mobile payment applications, highlighting the significance of perceived usefulness and perceived ease of use as influential determinants of users' attitudes and intents. Furthermore, the Mobile Acceptance Model (MAM) was established by Lu et al. (2020) to extend the Technology Acceptance Model (TAM) by incorporating perceived risk and trust as influential factors in determining individuals' inclination to utilise mobile devices for conducting financial transactions. Chen et al. (2021) adopted a comprehensive perspective by presenting the Unified Theory of Acceptance and Use of Technology (UTAUT), which extended the principles of the Technology

Acceptance Model (TAM) to encompass many technologies. Notably, their framework emphasised the role of performance as a crucial factor influencing the adoption of technology. These studies jointly highlight the versatility and resilience of the Technology Acceptance Model (TAM) in explaining the acceptance of technology across various sectors.

To sum up, the Technology Acceptance Model, which emerged in the late 1980s, has unquestionably made substantial advances to our comprehension of technology adoption. The versatility and continual development of this entity demonstrate its ongoing significance in both organisational and consumer settings. The adaptation of the Technology Acceptance Model (TAM) and its variations to accommodate the intricacies of forthcoming technological advancements is yet to be determined.

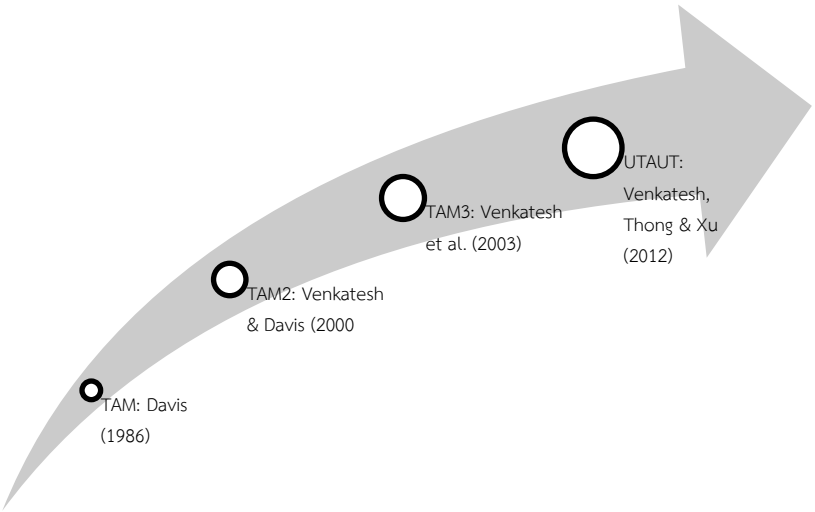

Figure 1 Evolution of TAM

In conclusion of this section, the Technology Acceptance Model (TAM) has solidified its position as a fundamental paradigm within the scholarly domain of technology adoption. Building upon the pioneering work of Davis, the Technology Acceptance Model (TAM) has consistently offered valuable insights

into the complex dynamics of individuals' perceptions and adoption of new technology. The technology landscape has experienced continuous changes, and the Technology Acceptance Model (TAM) has also demonstrated its flexibility by changing and adapting to meet growing difficulties. Although other adaptations such as TAM2 and UTAUT have been developed, the fundamental objective remains unchanged: comprehending user behaviour within the framework of technical progress. The adaptability of this technology is further demonstrated by its widespread implementation in numerous fields. While certain scholars raise concerns over its perceived lack of complexity, it is precisely this very attribute that has facilitated its extensive implementation and long-lasting existence. As we find ourselves on the cusp of further technological advancements, the fundamental principles of TAM serve as a guiding light. It is now the responsibility of the academic and professional communities to assure the ongoing refinement and relevance of TAM as a guiding framework in our ever-expanding interaction with technology.

CHALLENGES ASSOCIATED WITH TECHNOLOGY ACCEPTANCE MODEL (TAM)

The Technology Acceptance Model (TAM) has been widely regarded as a fundamental framework for comprehending the factors influencing users' acceptance and adoption of technology. Nevertheless, although it’s prevalent acceptance and substantial body of research supporting it (Ismagilova & Dwivedi, 2020; Huang & Chiu, 2021; Khan, Khan & Khan, 2021; Asare & Mensah, 2023), a number of obstacles have arisen with regards to its conceptualization and practical ramifications.

External Variables

The Technology Acceptance Model (TAM) functions as a theoretical framework for understanding the behaviour of individuals when it comes to adopting technology (Asare & Mensah, 2023). At the foundation of this concept lay two fundamental beliefs: the perception of usefulness (PU) and the

perception of ease of use (PEU). In essence, the concept of Perceived Usefulness (PU) entails the perception that the use of a specific technology would result in improved job performance. On the other hand, Perceived Ease of Use (PEU) suggests that employing this technology will need minimal exertion (Khan, Khan & Khan, 2021). Collectively, these factors constitute the foundational principles that frequently underpin determinations regarding the acceptance or rejection of technology. Nevertheless, this fundamental concept, although highly effective, cannot exist in isolation. The operation of the subject is situated within a wider framework that is subject to the effect of many external factors. We should examine some of these in more detail:

Table 1 Extensions and Modifications to Technology Acceptance Model (TAM)

	TAM	TAM2	TAM3	UTAUT
Origin/ Background	Davis initially created the Technology Acceptance Model (TAM) in the late 1980s (Davis, 1986)	Extension of TAM	Extension of TAM and TAM2	Integrates eight models including TAM & TAM2
Key Components or Focus Areas	-Perceived Usefulness (PU) -Perceived Ease of Use (PEOU) -Behavioral Intention (BI)	- Social Influence - Voluntariness -Cognitive Instrumental Processes	-Anchoring and Adjustment -Perceived Ease of Use Determinants -Perceived Usefulness Determinants	-Performance Expectancy - Effort Expectancy - Social Influence -Facilitating Conditions

Detailed Components or Determinants	TAM introduced three key notions: Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). These determine an individual's behavioral intention to use technology and their actual usage of it. PU reflects the belief in technology's ability to improve job performance, while PEOU represents the belief that technology is easy to use with minimal effort. Behavioral Intention (BI) influenced by both PU and PEOU, which determines actual technology usage.	- Subjective Norm - Job Relevance - Output Quality -Result Demonstrability	-Computer Self-Efficacy - Perceptions of External Control - Computer Anxiety -Computer Playfulness - Image - Job Relevance (also in TAM2) - Output Quality (also in TAM2) Result Demonstrability (also in TAM2)	- Gender (moderator) - Age (moderator) -Experience (moderator) -Voluntariness (moderator)

Organizational Culture

The organisational culture exerts a significant influence on employees' perceptions of emerging technologies. In a setting that cultivates creativity and promotes the investigation of technology, it is plausible that employees may possess a predisposition towards perceiving technology as advantageous and uncomplicated (Ismagilova & Dwivedi, 2020). It is possible that individuals may hold the belief that adopting the new system is congruent with the values of the organisation, hence leading to an improvement in their job performance. On the other, within a culture that is resistant to change or hostile to it, even the most advanced instruments may be regarded as superfluous or excessively intricate.

Individual Differences

Individuals possess a wide range of backgrounds, experiences, cognitive styles, and attitudes, all of which can exert a substantial influence on their interpretations and evaluations of technology. Certain individuals, as a result of previous experiences, may perceive a certain system to be more intuitive than others (Ismagilova & Dwivedi, 2020). On the other hand, individuals who have encountered technological difficulties in the past may approach a novel system with a sense of unease, so influencing their perception of ease of use (Huang & Chiu, 2021).

Training

Training provides individuals with the essential abilities and understanding required to effectively traverse a novel system. The implementation of effective training programmes has the potential to elucidate intricate procedures, so augmenting the user's self-assurance in navigating the technology and improving the perceived simplicity of the system (Huang & Chiu, 2021). Nevertheless, insufficient or inadequately organised training sessions might result in users experiencing a sense of being overwhelmed, so causing even a system that is designed to be user-friendly to appear intimidating.

Support

Continuous support, whether it is of a technical or managerial nature, provides consumers with the assurance that assistance will be readily available in the event that they have difficulties. The presence of a specialised staff or allocated resources can have an impact on consumers' perceptions. Individuals may exhibit a greater inclination to interact with technology, as they hold the belief that any potential obstacles will have minimal impact on their overall efficiency, hence augmenting their perceived usability (Huang & Chiu, 2021)).

Based on the aforementioned analysis, it is evident that the Technology Acceptance Model (TAM) offers a fundamental framework. However, it is important to acknowledge that practical situations involve numerous intricate layers of complexity. The influence of external influences on technology acceptance can often overwhelm the fundamental principles of the Technology Acceptance Model (TAM), underscoring the importance of adopting a comprehensive perspective to gain a true understanding of technology adoption. The observation can be likened to the perception of a tree within a dense forest, where the tree's intrinsic importance is acknowledged, but its overall well-being and development are heavily impacted by the surrounding ecological factors.

In summary, the fundamental concept of Technology Acceptance Model (TAM) revolves around the idea that the perceived usefulness (PU) and perceived ease of use (PEU) play crucial roles in determining the acceptance of technology. Nevertheless, it is important to acknowledge that various external factors, like organisational culture, individual characteristics, training, and assistance, can significantly impact the perception of usefulness (PU) and perceived ease of use (PEU). For example, the presence of a supportive organisational culture towards the adoption of technology might positively influence the perceived usefulness (PU) and perceived ease of use (PEU) of a new system (Venkatesh & Davis, 2000). Conversely, the absence of adequate training can impede the perceived level of user-friendliness when utilising a novel software, irrespective of its inherent

simplicity. The presence of intricate details serves to emphasise the intricate nature and unpredictable outcomes resulting from external factors, thereby indicating that the Technology Acceptance Model (TAM) is not comprehensive in its scope.

Model Simplification

The Technology Acceptance Model (TAM) has gained recognition in academic and professional spheres for its efficient methodology in comprehending the adoption of technology. The beauty of this concept resides in its ability to simplify the intricate phenomenon of technology acceptance by identifying two fundamental factors: perceived usefulness (PU) and perceived ease of use (PEU). Through its approach, TAM presents a model that is readily comprehensible, practical, and notably, capable of being reproduced in several contexts. Nevertheless, it is important to acknowledge that despite the positive aspects, any advantageous situation is accompanied by potential drawbacks. In the case of TAM, its distinguishing feature of simplicity could also expose it to vulnerabilities.

Social Influences

A notable deficiency of the Technology Acceptance Model (TAM) in the present-day setting is its inadequate consideration of social variables. In contemporary society, our opinions, attitudes, and behaviours are significantly influenced by several factors such as peer reviews, influencers, and the pervasive presence of social media (Liu & Li, 2023). For instance, in the context of technology adoption, the positive perception and ease of use of a tech tool by a user may be undermined by unfavourable reviews or comments received from their peer group, hence discouraging its adoption. Conversely, favourable recommendations from reliable peers or influencers can significantly impact the adoption of technology, even in cases when an individual may subjectively see the tool as rather difficult to navigate.

System Quality

Although the Technology Acceptance Model (TAM) emphasises the aspect of user-friendliness, it does not extensively examine the inherent excellence of the system. A software application may possess a user-friendly interface, yet it could also be plagued by various flaws or security risks. The Technology Acceptance Model (TAM) fails to sufficiently consider the impact of the inherent quality of a system on user acceptance (Elhaddad & Al-Shammari, 2022).

Trust

Trust plays a crucial role in the current era characterised by data breaches and heightened worries around privacy. Users may exhibit reluctance towards utilising even the most user-friendly and ostensibly advantageous applications if they lack confidence in the entities responsible for their development or harbour concerns over the security of their personal data (Al-Smadi, Ali & Alamri, 2021).

Essentially, although the Technology Acceptance Model (TAM) provides a robust basis for comprehending the acceptance of technology, it is imperative to regard it merely as an initial standpoint. As the integration of technology into our societal framework continues to advance, a model that just relies on perceived usefulness (PU) and perceived ease of use (PEU) may fail to encompass the complete range of factors that impact the adoption of technology.

In conclusion, the appeal of TAM lies in its inherent simplicity. However, the inherent simplicity of the subject matter also renders it susceptible to potential vulnerabilities. The Technology Acceptance Model (TAM) may overlook significant variables, including social influences, system quality, and trust, as it primarily focuses on perceived usefulness (PU) and perceived ease of use (PEU) (Legris, Ingham, & Collerette, 2003). In the present era, with the prevalence of social media platforms facilitating easy access to peer opinions, failing to include the role of social factors might lead to negative outcomes in understanding the full complexities of technological acceptance.

Cultural Context

The primary objective of the Technology Acceptance Model (TAM) is to offer a comprehensive framework that facilitates the comprehension of the factors influencing individuals' acceptance of technology and the underlying reasons for such acceptance. Although its implementation has been widespread and across several fields, the universal suitability of this concept becomes a subject of debate when considering multiple cultural contexts. The contribution of Hofstede's (2001, 2010) research on cultural factors is crucial in the context of this discourse. The author delineated several cultural factors that serve to distinguish one culture from another, including power distance, individuality versus collectivism, uncertainty avoidance, masculinity against femininity, and long-term versus short-term orientation. Each of these factors influences individuals' attitudes, beliefs, and behaviours, thereby impacting their interactions with and perceptions of technology.

Power Distance

This factor concerns the degree to which individuals in institutions and organisations with less authority acknowledge the unequal distribution of power. In cultures characterised by high power distance, there is a notable emphasis on hierarchical systems, where instructions issued by those in positions of authority are rarely subjected to questioning. Now, establish a connection between this phenomenon and the process of technological adoption (Kamkankaew et.al., 2023a). Within the context of this cultural setting, it can be observed that when a leader within an organisation makes the decision to adopt a specific technology, employees are inclined to utilise it, irrespective of their own assessments of its efficacy or user-friendliness. The extent to which individuals embrace a particular technology is influenced mostly by their deference to authority rather than by the fundamental notions of perceived usefulness (PU) and perceived ease of use (PEU) in the Technology Acceptance Model (TAM).

Individualism vs. Collectivism

Collectivist societies place a high value on collective consensus and harmony. In circumstances such as these, the acceptability of technology may be more susceptible to the effect of collective opinions rather than individual assessments of perceived usefulness (PU) and perceived ease of use (PEU). In the event that a collective perceives a tool to be advantageous, even individuals who have scepticism may be inclined to accept it in order to conform to the group.

Uncertainty Avoidance

Cultures characterised by a high degree of uncertainty avoidance exhibit a diminished capacity to tolerate ambiguity and typically exhibit a propensity to avoid situations that are unknown or uncertain. Certain cultures may exhibit resistance towards adopting new technology, which can be attributed to a broader reluctance to embrace change, rather than solely stemming from perceived usefulness or perceived ease of use.

Based on the complexities of culture, it becomes apparent that although the Technology Acceptance Model (TAM) provides a helpful basis for understanding, its components may exhibit variations when applied to diverse cultural contexts. This highlights the need of viewing TAM as a malleable instrument that should be customised and comprehended in consideration of distinct cultural intricacies.

In conclusion, the issue of the universality of Technology Acceptance Model (TAM) is subject to discussion when cultural settings are taken into consideration. The perceptions of perceived usefulness (PU) and perceived ease of use (PEU) can be significantly influenced by cultural aspects, as outlined by Hofstede (2001, 2010). In high power distance cultures, it is seen that employees may utilise technology mostly due to the imposition of their superiors, rather than being driven by personal perceptions of its utility or ease of use (Straub, Keil, & Brenner, 1997). The variability in cultural perceptions poses a difficulty to the universal applicability of the Technology Acceptance Model (TAM).

Evolution of Technology

In the contemporary era of digitalization, the advancement of technology is not merely evolving, but rather exhibiting a notable acceleration. Periodically, there emerge advancements that fundamentally reshape our comprehension of technology and its potentialities. The rapid advancement of technology has had significant ramifications for models and theories aimed at comprehending the interactions between humans and technology (Al-Nasser & Al-Shammari, 2020), such as the Technology Acceptance Model (TAM).

The concept of TAM was developed during a period characterised by the early stages of software applications and digital tools. The primary focus at that time revolved around facilitating the shift of individuals and organisations from manual procedures to digital alternatives. Hence, the approach revolves around two primary factors, namely perceived usefulness (PU) and perceived ease of use (PEU). This observation was applicable to the technological environment prevalent in the 1980s and 1990s (El-Haddad & Al-Shammari, 2023), as the primary focus was on the shift towards digital platforms and the imperative of guaranteeing their user-friendliness. In the present day, there has been a significant transformation in the technical landscape (Al-Qahtani & Alaqeel, 2020; Khan, Khan & Khan, 2021; Abdullatif & Sulaiman, 2022; Mahapatra & Jena, 2023)

Complex User Experiences

Contemporary technologies, particularly advancements such as augmented reality (AR) and virtual reality (VR), possess the capacity to provide more than just utility; they afford individuals immersive encounters (Khan, Khan & Khan, 2021). Users are not solely preoccupied with the conventional notion of a tool's utility; they also take into account aspects such as the level of immersion, realism, and interactivity. The conventional frameworks of perceived usefulness (PU) and perceived ease of use (PEU) may not fully contain the intricate evaluation factors in question.

New Learning Curves

Technologies such as quantum computing introduce principles that are fundamentally distinct from those of traditional computing. The learning curve encompasses not just the acquisition of proficiency in utilising a tool, but also the comprehension of novel paradigms. This exceeds the boundaries of the 'ease of use' concept as defined in the Technology Acceptance Model (TAM) (Mahapatra & Jena, 2023).

Emerging Concerns

The proliferation of networked devices and advanced artificial intelligence has brought about significant worries over data privacy, security, and ethical consequences. The aforementioned issues may have a substantial impact on the acceptability of technology, a dimension that is not necessarily addressed by the Technology acceptability Model (TAM) (Abdullatif & Sulaiman, 2022).

Diverse User Profiles

With the increasing democratisation of technology, its accessibility is expanding to a wider range of individuals. The user base has become more diverse, ranging from youngsters engaging with instructional augmented reality (AR) applications to senior citizens utilising virtual reality (VR) for therapeutic objectives (Al-Qahtani & Alaqeel, 2020). The motivations, apprehensions, and evaluation criteria of individuals can exhibit significant variation, which may not be comprehensively addressed by the generalised approach employed by the Technology Acceptance Model (TAM).

In light of these developments, it is important to acknowledge the limitations of the Technology Acceptance Model (TAM) within the contemporary and ever-changing technology environment, despite its enduring significance in the literature on technology acceptance. The proposition can be made that TAM can serve as a fundamental framework that can be further developed to accommodate the complex and evolving nature of modern technological interactions.

In conclusion, the rate at which technology is advancing is unparalleled. Although the Technology Acceptance Model (TAM) may have been suitable for software applications throughout the 1990s, its applicability to modern advancements such as augmented reality or quantum computing raises doubts. The aforementioned technological improvements present innovative user experiences that may not be fully encompassed by the static frameworks of the Technology Acceptance Model (TAM) (Tarhini, Hone, & Liu, 2013).

Subjectivity in Perceptions

The Technology Acceptance Model (TAM) utilises the constructs of "perceived usefulness" (PU) and "perceived ease of use" (PEU) as fundamental principles for comprehending the adoption of technology. The use of the phrase "perceived" is crucial as it intrinsically emphasises that the Technology Acceptance Model (TAM) is constructed based on individual perceptions. This aspect is significant as it both strengthens and weakens the model (Ismagilova & Dwivedi, 2020)

Variability in Perception

The nature of perception inherently involves subjectivity. It is influenced by a multitude of individual factors. According to Mahapatra & Jena (2023), consider two distinct user profiles: the first being an adolescent who has been exposed to cellphones from an early age, and the second being an elderly individual who encountered a computer for the first time around their fifties. Even in the event that they were to assess the identical application, it is probable that their subjective interpretations on its user-friendliness would exhibit substantial divergence (Kamkankaew et.al., 2023b). The reason for this discrepancy is not solely attributed to the application itself, but rather stems from the diverse technological backgrounds, experiences, and levels of comfort among users.

Cognitive Biases

Human perceptions are frequently subjective assessments that might be influenced by cognitive biases (Al-Smadi, Ali & Alamri, 2021). For instance, if a user has previously encountered an unfavourable encounter with a specific brand, they may exhibit confirmation bias by perceiving the brand's new software as less effective or more challenging to utilise, even in the absence of firsthand experience.

Comparative Evaluations

The perception of technology is often influenced by several external factors and does not typically manifest in isolation. Users may engage in the act of comparing a novel tool with a previously utilised one. If individuals have recently switched from using a highly intuitive application to a more feature-rich but less intuitive one, it is possible that their perceived ease of use (PEU) for the latter may be unfairly reduced (Hwang & Shin, 2022).

Learning Curve Impact

Certain technologies may have a more challenging learning process; however, they offer substantial advantages if proficiency is achieved. Users may initially perceive things as being less user-friendly. Nevertheless, this view has the potential to undergo significant transformation as time passes and individuals gain more experience. The static measurement of TAM may not adequately capture the dynamic nature of perception (Ismagilova & Dwivedi, 2020).

Considering the intricacies involved, it is important to acknowledge that while the Technology Acceptance Model (TAM) serves as a helpful foundation for comprehending the acceptance of technology, it is crucial for academics and practitioners to be cognizant of the model's inherent subjectivity. It is imperative to acknowledge that the Technology Acceptance Model (TAM) provides a framework, among several others, for comprehending the adoption of technology (Liu & Li, 2023). However, it is important to note that this framework is influenced by the subjective impressions of individuals. In order to improve the prediction

precision of the Technology Acceptance Model (TAM), it could be advantageous to complement it with qualitative insights that provide a more comprehensive understanding of the intricacies of individual experiences and perspectives.

In conclusion, the utilisation of "perceived" constructions in TAM introduces a certain degree of subjectivity. The perception of an application's complexity can vary among users, with some perceiving it as straightforward while others consider it to be complex. This variation can be attributed to factors such as past experiences, cognitive biases, and exposure to similar technology (Benbasat & Barki, 2007). The presence of subjective variance has the potential to introduce inconsistencies in both the applicability and predictive capacity of the Technology Acceptance Model (TAM).

Over-reliance on Quantitative Methods

The Technology Acceptance Model (TAM) has been widely recognised as a fundamental framework for comprehending the process through which people develop acceptance and adoption of a technology. The primary source of its effectiveness lies on the empirical validity of its constructs, namely "perceived usefulness" (PU) and "perceived ease of use" (PEU). The inclination to substantiate these notions by quantitative means arises from a pursuit of objectivity and wide-ranging applicability. Nevertheless, this numerical superiority carries significant consequences:

Limitation of Scope

Quantitative research necessitates the establishment of predetermined variables and hypotheses as part of its inherent design. Although this particular framework provides a sense of clarity, it simultaneously restricts the extent of investigation (Mahapatra & Jena, 2023). There are several factors, emotions, and experiences that can impact the adoption of technology, which may not be fully captured within the rigid parameters of a quantitative study.

Depth vs. Breadth

Quantitative methodologies, characterised by their utilisation of extensive sample sizes and statistical analysis, provide a comprehensive scope. For instance, it is possible for them to provide us with information indicating that a significant proportion of users perceive a given technology as being valuable (El-Haddad & Al-Shammari, 2023). However, they do not necessarily explore the underlying reasons for this sentiment. Qualitative research approaches, such as in-depth interviews or focus groups, offer the opportunity to explore the underlying motivations, concerns, and experiences of individuals.

Evolution of User Experience

The user experience undergoes transformation alongside the advancement of technology. Through the utilisation of technological advancements such as virtual reality and augmented reality, individuals are no longer merely engaging with a mere instrument, but rather, they are fully engrossed in a comprehensive and immersive encounter (Al-Nasser & Al-Shammari, 2020). Quantitative measurements can capture user engagement frequency and duration in relation to a particular technology, but they may fail to account for qualitative dimensions such as emotional resonance and the level of immersion experienced.

Diverse User Narratives

Each each user brings a distinct narrative to their engagement with technology, which is influenced by their personal background, previous encounters, and subjective prejudices. These tales provide the potential to provide valuable insights into the acceptability of technology, insights that may not be readily apparent in quantitative data alone (Elhaddad & Al-Shammari, 2022). For example, what are the reasons for the resistance exhibited by certain consumers towards a technology, even when they acknowledge its utility? Qualitative research has the potential to provide insights into these abnormalities.

Contextual Richness

Technologies do not operate in isolation; rather, they are integral components of broader ecosystems. The compatibility or conflict between a technology and its surrounding environment can significantly impact its level of acceptability (Huang & Chiu, 2021). Qualitative methodologies, characterised by their unstructured nature, has the ability to capture the intricate contextual intricacies, hence facilitating researchers in comprehending not just the extent of technology acceptance but also the manner in which it becomes interwoven within the daily lives of users.

Fundamentally, although quantitative methodologies have played a crucial role in establishing the credibility and applicability of the Technology Acceptance Model (TAM), there is an increasing consensus within the scholarly community about the significant contribution of qualitative insights in terms of depth and contextual understanding. In order to have a comprehensive understanding of technological (Kamkankaew wt.al., 2024a) adoption, it is crucial to integrate the wide applicability of quantitative methods with the intricate and nuanced insights provided by qualitative approaches.

In summary, research on Technology Acceptance Model (TAM) has primarily adopted a quantitative approach, with a significant emphasis on conducting statistical validations of its elements. Although quantitative methods offer a rigorous approach to testing, they may overlook the subtle complexities and complexity inherent in human-technology interactions. There is an increasing recognition among scholars that qualitative insights can provide a more comprehensive and contextual comprehension of technological acceptance behaviours, which may not be captured by simply quantitative evaluations (Bagozzi, 2007).

Challenges of Technology Acceptance Model after COVID-19 and Artificial Intelligence

Challenges after COVID-19

The Technology Acceptance Model (TAM) has been widely used to understand how users accept and adopt new technologies. It is based on two main constructs: perceived usefulness and perceived ease of use. However, the COVID-19 pandemic introduced several challenges that affect the relevance and application of this model in a post-pandemic world (Zobeidi et.al., 2023). These challenges arise from changes in user behavior, rapid technological advancements, and shifting societal priorities.

One of the primary challenges is the accelerated pace of digital transformation during the pandemic. Many organizations and individuals adopted technology out of necessity rather than preference (Kamkankaew et.al., 2024b). This forced adoption often bypassed the natural progression of technology acceptance as proposed by TAM. As a result, the model may no longer fully capture the complex motivations and barriers users face in a post-pandemic context (Van, Quynh & Doanh, 2024). For example, users who adopted video conferencing tools for remote work or online learning might continue using them even if they perceive them as less useful or difficult to use. This behavior challenges the core assumption of TAM that perceived usefulness and ease of use drive adoption.

Another issue is the increased demand for technology that supports well-being and social connection. The pandemic highlighted the importance of mental health and community, leading to the rise of technologies such as telehealth and virtual support groups (Ma & Luo, 2024). While TAM focuses on individual perceptions, it may not adequately address the role of social and emotional factors in technology adoption. For instance, users may prioritize emotional benefits, such as feeling connected to others, over traditional metrics like efficiency or ease of use.

Furthermore, the pandemic has widened the digital divide, making technology adoption more complex. Access to digital tools and infrastructure remains uneven, particularly in developing regions. TAM assumes that users have equal access to technology, but this is not the case in many parts of the world (Sudaryono et.al., 2024). Limited access can reduce perceived usefulness and ease of use, thereby lowering adoption rates. Additionally, users with limited digital literacy may face greater challenges in using new technologies, further complicating the application of TAM.

Finally, the pandemic has shifted societal expectations about technology. Users now expect technologies to be more flexible, secure, and sustainable. These expectations influence how individuals evaluate technologies, adding new dimensions to the acceptance process (Hanum et.al., 2023). For example, concerns about data privacy and environmental impact may discourage adoption, even if a technology is perceived as useful and easy to use.

In conclusion, while TAM remains a valuable framework for understanding technology adoption, it faces significant challenges in a post-COVID-19 world. Researchers and practitioners must consider new factors, such as forced adoption, emotional and social benefits, unequal access, and evolving user expectations. By addressing these challenges, TAM can be adapted to better reflect the complexities of technology adoption in the modern era.

Challenges with Artificial Intelligence

The Technology Acceptance Model (TAM) is widely used to understand how users adopt and accept new technologies (Panagoulias, Virvou & Tsihrintzis, 2024). It emphasizes two key factors: perceived usefulness (PU) and perceived ease of use (PEOU). However, when applied to artificial intelligence (AI), TAM faces several challenges due to the unique and complex nature of AI technologies (Mogaji et.al., 2024)

One of the main challenges is the dynamic and adaptive nature of AI. Unlike traditional technologies, AI systems can learn, evolve, and perform tasks without explicit programming. This characteristic makes it harder for users to fully understand how the system works, leading to uncertainty and mistrust. As a result, users may struggle to evaluate the usefulness and ease of use of AI technologies, limiting the applicability of TAM (Na et.al., 2023)

Another issue is the lack of transparency in many AI systems. AI algorithms, particularly those based on deep learning, often operate as "black boxes," where their decision-making processes are not easily understood by users (Hassija et.al., 2024). This lack of transparency can reduce user trust and confidence, directly impacting their acceptance of the technology. TAM does not fully address how transparency influences technology acceptance, making it less effective for studying AI adoption.

Ethical concerns and biases in AI also pose challenges to TAM. Users may reject AI systems if they perceive them as biased, discriminatory, or unethical (Khan, Khan & Aslam, 2024). For instance, if an AI system produces unfair outcomes, users may view it as neither useful nor acceptable. These concerns extend beyond the traditional scope of TAM, requiring additional frameworks to consider ethical and societal dimensions.

Lastly, the rapid advancement of AI technologies presents a challenge. As AI systems evolve, users' perceptions of usefulness and ease of use may change over time (Wang et.al., 2023). This dynamic nature of AI adoption is not fully captured by TAM, which assumes a relatively static evaluation process.

In conclusion, while the Technology Acceptance Model provides a useful foundation for understanding user adoption of technologies, its application to AI is limited by challenges related to the complexity, transparency, ethics, and evolving nature of AI systems. Addressing these challenges requires expanding TAM with additional factors and perspectives to better capture the unique characteristics of AI technologies.

In conclusion of this section, it can be unequivocally stated that the Technology Acceptance Model (TAM) has provided significant and indispensable contributions to the understanding of technology adoption and acceptance over an extended period of time. Nevertheless, with the continuous evolution of the technological landscape and the advancement of our comprehension about human-technology interactions, it is imperative to reevaluate, modify, and maybe enhance the Technology Acceptance Model (TAM) framework. Although the fundamental model is valuable, a more comprehensive and accurate representation of technological acceptance in the contemporary day can be achieved by acknowledging and overcoming its limitations.

Table 2 Challenges associated with Technology Acceptance Model (TAM)

Challenge	Description
Model simplification	The TAM's simplicity and focus on two key factors (perceived usefulness and perceived ease of use) can lead to it overlooking other important variables that may influence technology acceptance. These include social influences, system quality, trust, and cultural context.
Social influences	The TAM does not adequately account for the role of social influences, such as peer pressure, influencer endorsements, and social media, in technology adoption.
System quality	The TAM does not explicitly consider the impact of system quality, such as performance, reliability, and security, on user acceptance.
Trust	The TAM does not explicitly address the role of trust in technology adoption. Users may be hesitant to

	adopt new technologies if they do not trust the developers or the organizations that will be collecting and using their data.
Cultural context	The TAM is not universally applicable to all cultures. Hofstede's research on cultural factors suggests that different cultures have different values and beliefs that can influence technology acceptance.
After COVID-19 and Artificial Intelligence	The Technology Acceptance Model (TAM) must evolve to address post-COVID-19 and AI-related challenges. The pandemic revealed gaps in TAM's scope, such as emotional, social, and access disparities. Similarly, AI's complexity, ethical concerns, and dynamic user expectations challenge TAM's core constructs. Expanding TAM to include these factors ensures its continued relevance.

Limitations of Technology Acceptance Model (TAM)

The technological acceptance models, despite their significance in comprehending user adoption and utilisation of novel technologies, have not escaped criticism. This section provides further details regarding some significant constraints of these models.

Overemphasis on Behavioral Intention

The Technology Acceptance Model (TAM) and its subsequent revisions have had a substantial influence on the field of information systems research and the examination of technology adoption. Behavioural intention is a fundamental concept within the Technology Acceptance Model (TAM), serving as a predictor of consumers' inclination to embrace a specific technology. Nevertheless, despite its widespread acceptance and utilisation, there exist

dissenting perspectives within the academic community that question the overarching significance attributed to this particular concept.

Historical Perspective

The theoretical framework that places emphasis on behavioural intention finds its roots in the Theory of Reasoned Action (TRA) proposed by Fishbein and Ajzen (1975). The Theory of Reasoned Action (TRA) proposed that an individual's intention serves as the direct precursor to their behaviour. The Technology Acceptance Model (TAM), originally conceptualised by Davis (1989), incorporated and repositioned this particular notion as a means of forecasting technology adoption and utilisation.

Behavioral Intention vs. Actual Usage

The essence of the criticism is the difference between saying one is going to do something and actually carrying it out. The study conducted by Sheppard et al. (1988) clearly demonstrated that although intentions serve as robust predictors, they do not provide total certainty on subsequent behaviour. There are several occurrences wherein persons possess the intention to adopt a technology, yet encounter unforeseen conditions that hinder their ability to do so.

External Factors Impacting the Intention-Behavior Gap

Venkatesh and Davis (2000) discussed the influence of extrinsic influences on the link between intention and behaviour. The aforementioned elements, including system outages, task interruptions, and forced system use, are beyond the purview of the user's influence. Interruptions are frequently observed in real-world environments, hence challenging the notion that intention alone is an infallible predictor.

Voluntary vs. Mandatory Contexts

An additional aspect that merits emphasis is the contextual framework within which a technology is being implemented. In circumstances characterised

by voluntary participation, wherein users possess the agency to make independent choices about the utilisation of a given technology, it is plausible that the intention behind such usage may exhibit a more pronounced association with subsequent behavioural outcomes. Nevertheless, in obligatory contexts where individuals are compelled to utilise a particular technology, such as enterprise systems within various organisations, it is possible for the actual usage to remain high despite the presence of low behavioural intentions. This can be attributed to the pressures and obligations imposed by the work environment (Brown, Massey, Montoya-Weiss, & Burkman, 2002).

Expanding the Model

In light of these constraints, scholars have endeavoured to broaden the scope of the Technology Acceptance Model (TAM) by incorporating other variables beyond the realm of intention. These aspects encompass habit, which could elucidate the recurring use of technology despite a lack of intention to do so (Limayem, Hirt, & Cheung, 2007), as well as environmental influences that may hinder the adoption of technology despite a strong intention to utilise it.

To sum up, it is apparent that behavioural intention, although a fundamental aspect in the examination of technological acceptance, does not exist in isolation. The utilisation and acceptance of technology can be significantly influenced by several elements such as real-world limitations, user behaviour patterns, and organisational requirements. Consequently, researchers must take into account a wider array of considerations when attempting to forecast the adoption and usage of technology.

Neglect of Affective Factors into Emotional Dimensions in Technology Acceptance

The dominant focus in the realm of technology adoption and acceptance has been on cognitive factors, namely the conceptions of perceived usefulness and perceived ease of use. Nevertheless, as individuals engage with various systems and technology, their cognitive processes extend beyond mere

information processing and encompass a diverse range of emotional experiences (Kamkankaew et.al., 2023c). The impact of emotions on the acceptability of technology is significant, a factor that is frequently disregarded in conventional models.

The Interplay of Emotion and Cognition

The relationship between emotions and cognitive processes is highly interconnected. Although cognitive evaluations offer a logical appraisal of technology, emotions have the potential to enhance, diminish, or even modify these evaluations (Petty, DeSteno, & Rucker, 2001). For example, a system that elicits sensations of joy may be subjectively seen as more utilitarian than its empirical evaluation suggests.

Emotional Responses in Technology Use

Technology use can elicit a range of emotive responses from consumers. The potential factors contributing to this phenomenon include the design of the interface, the characteristics of the task, feedback received from the system, and prior experiences. Hassenzahl (2004) provides several instances of emotional responses, including pleasure, dissatisfaction, contentment, and anxiety.

Gaps in TAM

Although the TAM model is considered pioneering in certain aspects, it has received criticism for its failure to address emotional aspects. The emphasis on cognitive assessments in its approach may result in a potential oversight of the multifaceted nature and profoundness of the user's experience. According to Beaudry and Pinsonneault (2010), emotions can exert both direct and indirect influences on the utilisation of information technology.

Efforts in Later Models

Subsequent models, such as TAM3 and UTAUT, sought to encompass a broader range of the user's experience; nonetheless, these efforts remained primarily tangential in nature. The constructs present in the Unified Theory of

Acceptance and Use of Technology (UTAUT), such as "experience," may consider the length of time during which a system is utilised, but they do not extensively explore the subjective quality of that experience, namely the emotional process that users undertake (Venkatesh & Bala, 2008).

Need for Emotion-centric Frameworks

The absence or gap in prevailing technological acceptance models requires the development of frameworks that explicitly integrate emotions. Affective elements have the potential to function as moderators or mediators in the association between cognitive judgements and behavioural intentions. By comprehending these emotional pathways, researchers and practitioners have the ability to develop systems that possess not just functional competence but also emotional engagement.

In summary, inside the continuously developing domain of technology adoption, it is of utmost importance to comprehend the comprehensive user experience. Although models such as the Technology Acceptance Model (TAM) have made significant contributions, it is crucial to incorporate the emotional aspects of consumers in order to fully understand the complexities of technology acceptance.

The Limitations of Technology Acceptance Model (TAM), TAM2, TAM3 and UTAUT

Throughout the progressive evolution of models that seek to elucidate the acceptance and utilisation of technology, a sequence of adjustments has been implemented in order to effectively address the critiques directed towards earlier models. This section provides a more comprehensive analysis of the constraints associated with the Technology Acceptance Model (TAM), TAM2, TAM3, and the Unified Theory of Acceptance and Use of Technology (UTAUT).

1. Limitations of TAM

The initial iteration of the Technology Acceptance Model (TAM) was established with the aim of establishing a foundation for comprehending the mechanisms underlying user acceptance.

Simplicity: The primary advantage of this approach lies in its simplicity, although this very characteristic also imposes a constraint on its effectiveness. The inherent simplicity of the phenomenon frequently resulted in the disregard of crucial external components, such as the aforementioned social impacts or conducive situations (Legris, Ingham, & Collerette, 2003).

Evolution of Technology: The Technology Acceptance Model (TAM) overlooks the dynamic nature of technology and its evolving relationship with people, thus diminishing its applicability in the context of emerging technologies.

2. Limitations of TAM2

In order to address these limitations, TAM2 integrated additional variables inside its conceptual framework.

Dynamism: Despite the developments in Technology adoption Model (TAM), it has been observed that TAM2 fails to comprehensively capture the dynamic character of technology adoption. In particular, it does not adequately account for the changes in user perceptions that occur as users become more familiar with the technology (Venkatesh & Davis, 2000).

Specificity: The TAM2 framework has a higher level of specificity compared to TAM, however it may still overlook distinctive features that are relevant to certain technological situations.

3. Limitations of TAM3

Subsequent iterations of the model resulted in the development of TAM3, which incorporated more determinants.

Redundancy: The introduction of TAM3 brought in a higher level of comprehensiveness; nevertheless, it also resulted in many constructions

becoming redundant due to the increased complexity. According to Venkatesh and Bala (2008), the presence of redundancy in the model can pose challenges for practitioners, making it difficult to effectively utilise.

Usability: Utilisation of TAM3 may provide challenges for companies or researchers lacking a comprehensive understanding of its intricacies.

4. Limitations of UTAUT

The UTAUT was established with the aim of synthesising different models in a determined endeavour.

Complexity: The complete character of the Unified Theory of Acceptance and Use of Technology (UTAUT) poses challenges for its universal implementation. Every construct necessitates meticulous deliberation, hence rendering the procedure laborious.

Cultural Context: One such criticism pertains to the universal nature of the Unified Theory of Acceptance and Use of Technology (UTAUT). In the pursuit of global applicability, there is a potential risk of overlooking crucial cultural nuances that have a substantial influence on behaviours related to the acceptance of technology (Al-Gahtani, Hubona, & Wang, 2007).

Customization: The UTAUT model's broad framework necessitates potential customization by organisations in accordance with unique contextual factors, hence imposing limitations on its overall applicability.

Although these models provide valuable frameworks for comprehending the acceptability of technology, it is imperative to acknowledge their inherent limits. As technology and society progress, there persists a continuous requirement to enhance existing models or develop novel ones capable of comprehensively representing the ever-changing dynamics of user technology interactions across many contexts.

In conclusion of this section, the evolution from TAM to UTAUT signifies a deliberate endeavour to enhance the comprehensiveness and relevance of technology acceptance models. Nevertheless, like any theoretical framework,

each of these models possesses inherent limitations and opportunities for further enhancement. Future models should take into account a well-rounded strategy that encompasses both simplicity for practical application and depth to accommodate many user contexts and cultural backgrounds.

Table 3 Overview of Limitations of Technology Acceptance Model (TAM)

Limitations	**Explanation**
Overemphasis on Behavioral Intention	TAM and its subsequent revisions focus on behavioral intention as the main predictor of technology adoption and usage. However, some researchers argue that behavioral intention is not always a reliable predictor of actual behavior.
Neglect of Affective Factors	TAM does not explicitly consider the role of emotions in technology acceptance. However, emotions can play a significant role in how people perceive and use technology.
Simplicity	TAM is a relatively simple model, which makes it easy to understand and use. However, this simplicity also means that TAM does not account for all of the factors that can influence technology acceptance.
Evolution of Technology	TAM was developed in the late 1980s, and it does not fully account for the rapid pace of technological change. Emerging technologies may have different characteristics that affect how people adopt and use them.
Dynamism	TAM does not adequately capture the dynamic nature of technology adoption. Over time,

	people's perceptions of technology can change as they become more familiar with it.
Specificity	TAM is a general model of technology acceptance, and it may not be able to account for the unique features of all technologies.
Redundancy	Later iterations of TAM, such as TAM3, have become more complex by incorporating additional variables. This can lead to redundancy and make the model more difficult to use.

Table 4 Limitations of Technology Acceptance Model (TAM), TAM2, TAM3 and UTAUT

	TAM	**TAM2**	**TAM3**	**UTAIT**
Overemphasis on behavioral intention	Yes	Yes	Yes	Yes
Historical perspective	Yes	Yes	Yes	Yes
Behavioral intention vs. actual usage	Yes	Yes	Yes	Yes
External factors impacting the intention-behavior gap	Yes	Yes	Yes	Yes
Voluntary vs. mandatory contexts	Yes	Yes	Yes	Yes
Expanding the model	Yes	Yes	Yes	Yes
Neglect of affective factors into emotional	Yes	Yes	Yes	Partially

dimensions in technology acceptance				
Simplicity	Yes	No	No	No
Evolution of technology	Yes	Yes	Yes	Partially
Dynamism	No	Yes	Yes	Partially
Specificity	No	No	Yes	Partially
Redundancy	No	No	Yes	Yes

Note: Yes, *means that the limitation is present in the corresponding technology acceptance model;* ***No,*** *means that the limitation is not present in the corresponding technology acceptance model;* ***Partially,*** *means that the limitation is addressed to some extent in the corresponding technology acceptance model, but not fully.*

Implication and Future Research Possibilities

This article has explored the robust yet evolving framework of the Technology Acceptance Model (TAM) and its iterations, which offer deep insights into user behavior concerning new technologies. Despite the model's widespread adoption and utility across various fields, it faces criticism for its limitations, particularly its simplicity and the lack of consideration for external, emotional, and contextual factors affecting technology acceptance.

Managerial Implication for Organization Management

1. Effective technology integration in organizations requires comprehensive training programs to bridge the knowledge gap among employees. Training sessions should focus on improving employees' confidence and skills in using new systems, thereby enhancing the perceived ease of use. Additionally, continuous technical and managerial support can mitigate the apprehension associated with adopting advanced technologies, ensuring

smoother transitions and better user satisfaction. This approach aligns with the Technology Acceptance Model's emphasis on user-friendly and supportive environments to foster technology acceptance.

2. The acceptance of technology within an organization is significantly influenced by its culture. Managers should cultivate a culture that encourages innovation and embraces technological advancements. By creating a positive environment that values technology as a tool for enhancing job performance, organizations can improve employees' perception of its usefulness. Conversely, resistance to change can hinder acceptance, even for technologies that are inherently efficient and user-friendly. Therefore, fostering an open and adaptive organizational mindset is crucial for successful technology implementation.

3. Managers should recognize the emotional and social factors that influence technology acceptance. For example, incorporating social feedback mechanisms, such as peer recommendations and collaborative platforms, can increase trust and confidence in new systems. Moreover, addressing users' emotional responses, such as anxiety or frustration, by designing intuitive interfaces and providing timely assistance, ensures a more inclusive approach. Considering these dimensions will not only enhance technology acceptance but also improve overall employee engagement and productivity.

Table 5 Managerial Implication for Organization Management

Implication	**Description**	**Key Focus Areas**
Effective Technology Integration	Comprehensive training programs are essential to bridge the knowledge gap among employees. Training should focus on improving confidence and skills in using new systems, ensuring smoother	-Employee training - Perceived ease of use -Managerial support

	transitions and enhanced user satisfaction. Continuous technical and managerial support is critical.	-Technology Acceptance Model
Cultivating a Technology-Friendly Organizational Culture	The acceptance of technology is significantly influenced by organizational culture. Managers should foster a culture of innovation, adaptability, and openness to technological advancements. Resistance to change should be minimized to facilitate successful implementation.	-Innovation culture -Resistance to change -Perceived usefulness
Addressing Emotional and Social Factors	Managers should consider emotional and social aspects by incorporating mechanisms like social feedback and collaborative platforms. Intuitive interfaces, timely assistance, and addressing user anxieties ensure inclusivity, better acceptance, and improved engagement and productivity.	- Social feedback -Emotional responses -Intuitive interface design - Timely assistance

Managerial Implication for Online Marketing

1. Online marketing strategies must prioritize user-friendly designs and seamless navigation. Building on the principles of perceived usefulness and ease of use, websites, and apps should be tailored to meet the needs of diverse audiences. For example, personalized recommendations, intuitive interfaces, and

adaptive features can enhance user satisfaction and engagement. Businesses should employ user-testing mechanisms to continually refine their platforms based on consumer feedback.

2. Trust plays a critical role in digital marketing success. Marketers must ensure that their platforms are transparent and secure to build consumer confidence. Clear privacy policies, visible security badges, and trustworthy payment systems can reduce skepticism among users. Regular updates about data protection measures can further solidify trust, especially in industries like e-commerce and financial services.

3. social media and peer reviews are significant factors influencing consumer behavior in the online space. Marketers should integrate strategies like influencer collaborations, user-generated content, and social proof into their campaigns. These initiatives leverage the collective opinions of communities to foster brand credibility and drive customer engagement.

4. Online marketing strategies must acknowledge and adapt to cultural differences to succeed in global markets. For instance, understanding local preferences, language nuances, and cultural values can improve the relevance and resonance of marketing messages. Tailored content and region-specific campaigns can help businesses connect more effectively with diverse audiences and achieve broader acceptance of their digital platforms.

Table 6 Managerial Implication for Online Marketing

Implication	Description	Examples/Key Practices
Online Marketing Strategies	Prioritize user-friendly designs and seamless navigation based on principles of perceived	Personalized recommendations, intuitive interfaces, adaptive features, and user-testing mechanisms

	usefulness and ease of use.	to refine platforms based on consumer feedback.
Trust and Security in Marketing	Emphasize transparency and security to build consumer confidence.	Clear privacy policies, visible security badges, trustworthy payment systems, and regular updates about data protection measures.
Leveraging Social Influence	Utilize social media and peer reviews to influence consumer behavior.	Strategies such as influencer collaborations, user-generated content, and social proof to foster brand credibility and engagement.
Cultural Adaptation	Acknowledge and adapt to cultural differences for global market success.	Tailored content, region-specific campaigns, understanding of local preferences, language nuances, and cultural values to enhance message relevance and acceptance.

Managerial Implication for new ideas in today's fast-changing world

1. As technological innovations rapidly evolve; organizations should prioritize user-centric design to foster acceptance and engagement. Managers need to emphasize simplicity, usefulness, and emotional satisfaction in technology deployment. Incorporating user feedback during development ensures that the technology aligns with actual needs, reducing resistance and increasing efficiency. This approach is particularly essential for technologies

introduced in high-pressure or post-crisis environments, where users may have limited time to adapt.

2. Emotional and social dimensions increasingly influence consumer and employee adoption of new ideas and tools. Managers must consider these factors in decision-making, whether introducing digital tools for creating customer experiences. By addressing trust issues, ethical concerns, and emotional benefits such as connection and well-being, businesses can build deeper relationships and foster loyalty. For example, providing transparent and ethical AI solutions can alleviate concerns about misuse or discrimination.

3. Continuous learning and real-time support are critical in today's environment of complex, evolving technologies. Managers should invest in training programs that are interactive and adaptive, ensuring employees and customers have the skills to use new systems effectively. Offering comprehensive technical support also builds confidence in adopting innovations. This dual focus on education and assistance is especially relevant for technologies like AI, where the learning curve is steep and transparency is often low.

4. A culture of collaboration and flexibility enables organizations to embrace change and innovation more effectively. Leaders must encourage teamwork and adaptability, ensuring employees are open to exploring and implementing new ideas. Flexibility in adopting different cultural approaches also supports global operations. For instance, accommodating local cultural factors in technology deployment strategies ensures smoother integration and higher acceptance rates.

5. Technology adoption is not static; it evolves as users' familiarity and the surrounding ecosystem change. Managers must recognize this dynamic by consistently monitoring user behavior and adjusting strategies accordingly. Additionally, businesses must tailor their approaches to different contexts, ensuring technologies meet specific organizational or regional needs. Proactive

efforts in this regard help organizations stay competitive in a rapidly shifting technological landscape.

Future Research

1. Future research should explore how emotional factors influence technology acceptance, as emotions are crucial in shaping user perceptions. While TAM primarily focuses on cognitive aspects, such as perceived usefulness and ease of use, it neglects the emotional dimensions that can drive or hinder technology adoption. Researchers could develop models that integrate emotional constructs, such as user satisfaction, trust, and enjoyment, to provide a more holistic understanding of technology acceptance in diverse contexts.

2. With the rapid development of advanced technologies like artificial intelligence, augmented reality, and quantum computing, TAM's current framework may not adequately capture the unique characteristics and challenges associated with these innovations. Future studies should modify TAM to include factors such as transparency, ethical concerns, and system interactivity. This would help in understanding how users evaluate and adopt highly complex and adaptive systems.

3. Cultural differences significantly influence technology adoption, yet TAM's universal framework does not fully account for these variations. Future research could adapt TAM to specific cultural settings by incorporating dimensions like power distance, individualism vs. collectivism, and uncertainty avoidance. Comparative studies across different cultural groups would provide valuable insights into how cultural factors shape technology acceptance, enabling the development of more context-sensitive models.

Table 7 Managerial Implication for new ideas in today's fast-changing world

Implication	Description	Examples
User-Centric Design	Prioritize simplicity, usefulness, and emotional satisfaction in technology deployment. Use user feedback to align with actual needs, reducing resistance and increasing efficiency.	Implement user-friendly interfaces for digital tools in high-pressure environments, such as post-crisis management systems.
Emotional and Social Dimensions	Address trust, ethical concerns, and emotional benefits like connection and well-being to foster adoption and loyalty.	Provide transparent AI solutions to alleviate misuse concerns and emphasize emotional benefits in employee engagement platforms or customer experiences.
Continuous Learning and Real-Time Support	Invest in adaptive training programs and technical support to build user confidence and skills.	Develop interactive AI training modules and offer 24/7 technical support to help employees and customers overcome steep learning curves and understand opaque systems.

Collaboration and Flexibility	Foster teamwork and adaptability to enable effective exploration of new ideas. Adjust strategies to local cultures for smoother technology integration.	Introduce cross-functional teams to drive innovation and tailor global technology strategies by accommodating local cultural factors, such as language preferences or work styles.
Dynamic Technology Adoption	Continuously monitor user behavior and adjust strategies to evolving needs and contexts. Tailor technology to meet specific organizational or regional demands.	Use analytics to track adoption trends and refine deployment strategies based on user feedback. For example, adjust software functionality for regional-specific business processes in global operations.

Conclusion

In conclusion, the Technology Acceptance Model (TAM) has undoubtedly played a pivotal role in advancing our understanding of technology adoption over the years. Its simplicity, built on the concepts of perceived usefulness and ease of use, has made it widely applicable across diverse contexts. However, the dynamic and complex nature of modern technology adoption exposes several limitations of TAM. The model often overlooks external factors such as organizational culture, trust, and system quality, which significantly influence user

behavior. Furthermore, its focus on cognitive aspects neglects the emotional dimensions that are increasingly relevant in today's technologically immersive environments. As technology evolves rapidly, TAM must adapt to include broader constructs that reflect the intricate interplay of cognitive, affective, and social influences on user behavior. Future research should prioritize developing comprehensive frameworks that address these gaps, ensuring TAM remains a relevant tool for understanding technology adoption in both academic and practical applications. By integrating diverse perspectives and addressing its limitations, TAM can continue to provide meaningful insights into the complexities of human-technology interactions.

Table 8 Future Research

Future Research Area	**Key Focus**	**Proposed Actions**
Emotional Factors in Technology Acceptance	Addressing the emotional dimensions that influence user perceptions and technology adoption, which are neglected in the traditional TAM framework.	Develop models integrating emotional constructs such as user satisfaction, trust, and enjoyment to provide a holistic understanding of technology acceptance in diverse contexts.
Adaptation to Advanced Technologies	Understanding how TAM's framework can evolve to address challenges and characteristics of advanced	Modify TAM to include factors like transparency, ethical concerns, and system interactivity, which are

	technologies like AI, AR, and quantum computing.	critical for evaluating and adopting highly complex and adaptive systems.
Cultural Sensitivity in Technology Adoption	Exploring how cultural differences impact technology adoption, which is inadequately addressed in TAM's universal framework.	Adapt TAM to specific cultural settings by incorporating cultural dimensions (e.g., power distance, individualism vs. collectivism, uncertainty avoidance) and conducting comparative studies across different cultural groups.

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