

Modeling Digital Intention in Emerging Economies: A Comparative Discussion of TAM vs. UTAUT for Assessing BIM and AEC IT Adoption in Developing Countries (2020–2025)

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ABSTRACT

The global architectural, engineering, and construction (AEC) industry is undergoing a profound digital transformation driven by the adoption of Building Information Modelling (BIM). However, the actual uptake in emerging economies remains constrained by a confluence of unique socio-economic and infrastructural challenges. This paper critically evaluates technology acceptance theories from 2020–2025, addressing the methodological debate between the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT). Utilising a Systematic Comparative Review (SCR), the study identifies an "explanatory ceiling" in TAM when applied to organisational settings. Consequently, the research establishes a methodological imperative for UTAUT, which formalises Social Influence (SI) and Facilitating Conditions (FC) to better model the professional hierarchies and fragmented infrastructures of developing nations. By strategically focusing on Behavioural Intention (BI) and omitting 'Actual Use' (AU), the study provides a robust, context-sensitive roadmap for digital innovation in resource-scarce environments.

Keywords: Building Information Modelling (BIM), UTAUT, Developing Countries, Behavioural Intention, Technology Acceptance.

INTRODUCTION

The global architectural, engineering, and construction (AEC) industry is currently undergoing a significant transformation driven by the widespread adoption of Building Information Modelling (BIM) (Mata et al., 2024). This paradigm shift, characterised by the integration of information and communication technologies, policies, and procedures, aims to enhance project efficiency, reduce costs, and improve collaboration across various project phases (Rinchen & Banihashemi, 2024; Shehzad, 2022). Consequently, the strategic implementation of BIM and associated AEC IT software is now viewed as a critical success factor for modern construction projects worldwide. Despite these documented benefits, the actual uptake of advanced technologies in emerging economies remains constrained by a confluence of unique socio-economic, technological, and infrastructural challenges (Ata et al., 2024a; Musleh, 2018). In these environments, the non-adoption of BIM persists due to a complex interplay of organisational and behavioural factors among professional engineers and practitioners, necessitating a deeper investigation into the drivers of digital transition within resource-scarce contexts.

Understanding the decision-making processes—specifically the Behavioural Intention (BI)—of these professionals is paramount to designing effective intervention strategies and policies. Addressing this challenge requires a robust theoretical framework capable of elucidating the behavioural drivers of AEC professionals towards BIM adoption. To date, the academic community has primarily relied on foundational models like the Technology Acceptance Model (TAM) and the more comprehensive Unified Theory of Acceptance and Use of Technology (UTAUT) to study this phenomenon, sparking an ongoing methodological debate regarding which model provides the most accurate and context-sensitive predictions. This paper critically reviews the application and performance of these theories within the AEC domain from 2020 to 2025. Our central thesis is that UTAUT offers the most optimal and comprehensive methodological approach for understanding BIM adoption,

particularly within non-voluntary, organisational settings characterised by the unique cultural, political, and economic dynamics of developing countries. By comparing the structural completeness and predictive validity of TAM and UTAUT against the specific requirements of the developing country AEC context, this study establishes the methodological imperative for using UTAUT as the superior model for empirical investigations in nascent markets.

Theoretical Foundations: The Dominant Models and Their Limitations

To address the challenge of low BIM adoption in developing countries, a robust theoretical lens is required to capture the complex Behavioural, social, and organisational factors influencing professional engineers. The field of Information Systems (IS) has yielded several foundational models, chief among them the Theory of Reasoned Action (TRA), the Theory of Planned Behaviour (TPB), and the TAM. These models form the methodological starting point for most AEC technology adoption studies.

The Antecedents of Acceptance: TRA and TPB

The initial attempts to model volitional behavior are rooted in social psychology. The TRA (Ajzen & Fishbein, 1980) posits that an individual's Behavioural Intention (BI) to perform a behavior is the primary determinant of that behavior, with intention shaped by the individual's Attitude towards the behavior and their perception of Subjective Norms. This linear model was foundational for predicting volitional actions. Ajzen (1985, 1991) introduced the TPB as an expansion of TRA, primarily to address behaviors over which individuals have incomplete volitional control, a common scenario in organisational IT adoption. TPB introduced Perceived Behavioural Control (PBC) as a third, fundamental determinant of both BI and actual behavior. This addition proved critical for understanding real-world technology use, particularly at the organisational level. While TRA and TPB provide conceptual structures for predicting behavior changes, their direct application in technology contexts was simplified by the introduction of the Technology Acceptance Model. Based on the literature review, the core constructs form the basis of the current investigation are presented in Table 1.

Table 1: Operational Definitions and Theoretical Sources for the Primary Research Constructs

Main Factor	Sub-Factors	Definition	Key Sources
Behavioural Intention	—	The willingness of the person to adopt BIM.	Ajzen (2020), Wang (2023)
Attitude	—	Subjective evaluation of the adoption process.	Davis (1989), Nguyen (2023)
PU / PE	—	Subjective evaluation of BIM's utility and performance.	Chi et al. (2022), Wang (2023)
PEOU / EE	—	Belief that the technology requires minimal effort.	Widiar et al. (2023), Murguia (2023)
BIM Perceptions	People	Human aspects: training, skills, change management.	Cui et al. (2021a), Sanchís Pedregosa (2020)
BIM Perceptions	Process	Redesigning workflows and management practices.	Chi et al. (2022), Zeng & Wen (2023)
BIM Perceptions	Technology	Integrating BIM software tools in AEC.	Mohamad & Khalid (2020)

The Technology Acceptance Model (TAM)

The TAM, developed by Davis (1989), evolved directly from TRA and TPB, situated within the cost-benefit paradigm of Behavioural decision theory.

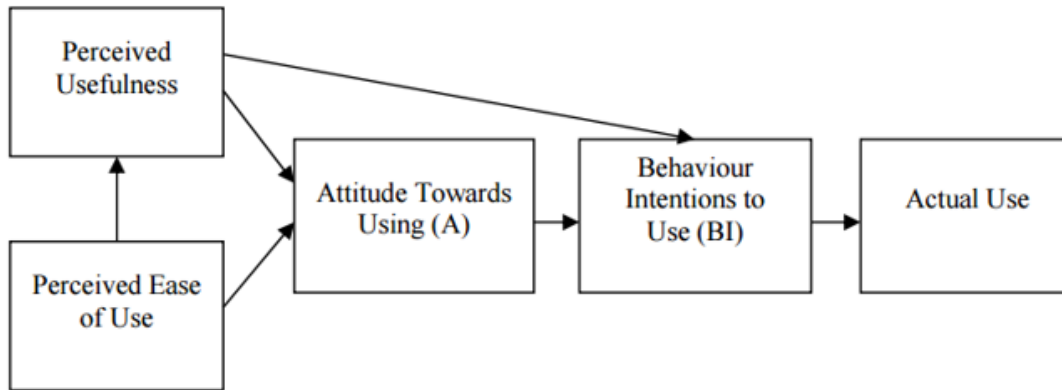


Figure 1 Technology Acceptance Model (Davis et al., 1989)

TAM streamlined its antecedents, proposing that user acceptance is fundamentally driven by two core cognitive beliefs:

- **Perceived Usefulness (PU):** The extent to which a user believes that using the technology (e.g., BIM) will enhance their job performance.
- **Perceived Ease of Use (PEOU):** The degree to which a user believes that using the technology will be free of effort.

TAM posits that PU and PEOU shape the user's Attitude toward the technology, which, in turn, influences their Behavioural Intention (BI) and eventual Actual Use (AU). Due to its simplicity, parsimony, and high degree of validation across various systems, TAM quickly became the most widely applied theoretical framework for explaining technology usage (Dumpit et al., 2017; Venkatesh et al., 2016).

The Use of TAM in BIM and AEC Research

The original TAM has been frequently utilized in AEC literature to investigate BIM adoption dynamics, largely due to its methodological rigor and predictive capacity (Nnaji et al., 2023). Studies have successfully applied TAM to assess key constructs like PU and PEOU among construction professionals in various contexts (S. Lee et al., 2015; Xu et al., 2014; Enegbuma, 2016). Recent research underscores that acceptance of technologies like BIM significantly relies on these constructs, particularly in newly modernizing sectors (Hamza et al., 2023). Furthermore, the simplicity of TAM allows for easy extension with external factors (e.g., BIM Perceptions related to People, Process, and Technology, offering researchers a flexible means to tailor the model to BIM-specific challenges (Rotimi et al., 2022).

However, as research on complex, organisational, and context-dependent technologies like BIM has matured, the limitations of the original TAM have become increasingly apparent, particularly within the unique socioeconomic environment of developing countries. While TAM is simple, its focus on individual cognitive beliefs often results in an explanatory ceiling when applied to mandatory or organisational settings.

Specifically, the original TAM:

1. **Undermodels Social Influence:** It minimizes the impact of social factors and organisational mandates, which are crucial in the hierarchical and relationship-driven construction sector, particularly where cultural norms hold strong sway (Venkatesh et al., 2003).

2. **Lacks Contextual Depth:** It lacks explicit constructs to account for the role of infrastructural barriers and facilitating conditions (e.g., lack of government policy, poor IT readiness) that pose defining challenges to adoption in developing countries.

These recognized limitations in TAM necessitate the evaluation of a more integrated and sociologically informed theoretical framework, leading to a critical discussion of the UTAUT.

Defining the Contextual Criteria: The Developing Country Conundrum

While the TAM offers a parsimonious framework for understanding individual-level technology acceptance, its structural simplicity proves inadequate when applied to the complex, organisational adoption of BIM/AEC IT in developing countries. To select the optimal theoretical lens, one must first define the unique, high-impact inhibitors characteristic of this specific environment. The research indicates that any effective Behavioural model for developing country AEC must capture the following three critical adoption criteria, which form the primary limitations of the original TAM model:

Criterion A: Strong Hierarchy and Social Norms (The SI Gap)

Construction industries in many developing nations operate within highly hierarchical, relationship-driven, and often culturally collectivist business environments. In these settings, Social Norms and the expectation of influential stakeholders (senior management, government bodies, or powerful clients) carry significant weight—often superseding individual cognitive beliefs (PU/PEOU). TAM's primary focus on individual attitude and belief, and its weak conceptualization of social influence, fails to capture this decisive factor, leading to an unexplained variance when the technology adoption is organisational and non-voluntary.

Criterion B: Limited Digital Infrastructure (The FC Gap)

The transition to BIM necessitates substantial technical capacity, including adequate hardware, reliable high-speed internet, specialized software licenses, and IT support. In developing countries, this essential digital infrastructure is often fragmented, cost-prohibitive, and unreliable. TAM lacks any dedicated construct to model the influence of these external, non-user-controllable factors. BIM acceptance may be high (high PU), but without the Facilitating Conditions required to run the software, adoption is impossible.

Criterion C: Low Perceived Facilitating Conditions (The Training/Support Gap)

Related to infrastructure, developing country AEC firms often face a lack of structured BIM training programs, high turnover of skilled personnel, and insufficient governmental standardization or technical support. This results in a low Perceived Facilitating Condition among engineers, which acts as a powerful inhibitor to Behavioural Intention. The limited scope of TAM means these critical external barriers are typically relegated to poorly defined "external variables" rather than being integral components of the predictive structure, thereby undermining the model's diagnostic utility.

Given that these three contextual inhibitors (Strong Hierarchy/Social Norms, Limited Infrastructure, and Low Facilitating Conditions) are defining features of BIM adoption failure in the developing world, the selection of an alternative model—one that explicitly and robustly captures the influence of social and environmental factors—is not merely optional, but a methodological imperative.

The UTAUT

Building upon the foundations and addressing the inherent limitations of TAM and its predecessors, Venkatesh et al. (2003) developed the UTAUT, see figure 2. UTAUT is a meta-model, consolidating constructs from eight established theoretical frameworks (including TRA, TPB, and TAM), making it a unified and comprehensive framework for understanding user behavior, especially in organisational settings.

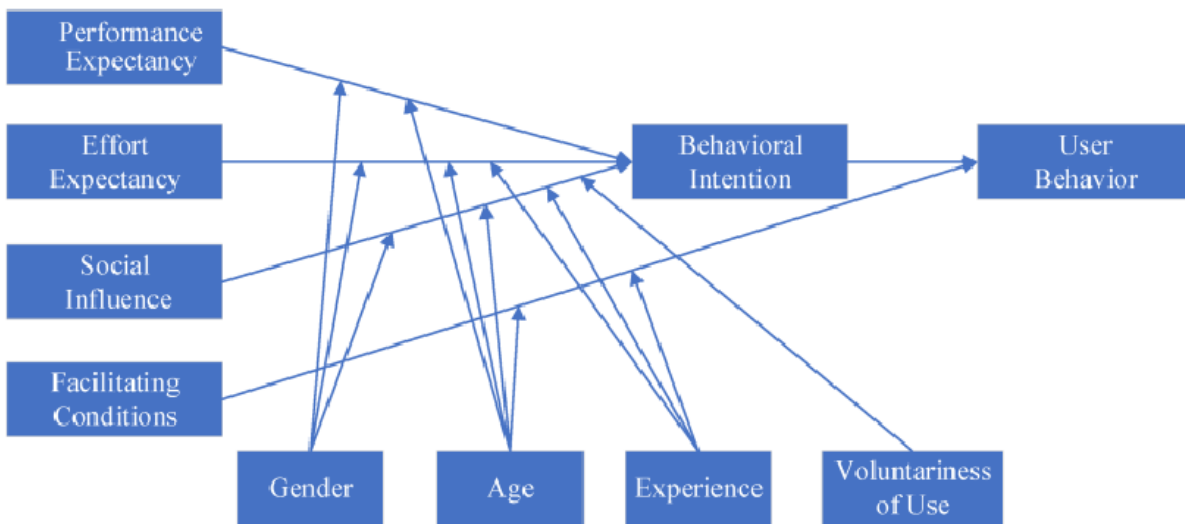


Figure 2 Original UTAUT Model Source: (Venkatesh et al., 2003)

UTAUT identifies four core constructs that influence Behavioural Intention (BI) and eventual Usage Behavior:

Performance Expectancy (PE): The belief that the system will enhance job performance (similar to TAM's PU).

Effort Expectancy (EE): The perceived ease of system use (similar to TAM's PEOU).

Social Influence (SI): The degree to which an individual perceives that important stakeholders (e.g., managers, colleagues, or clients) expect them to use the system.

Facilitating Conditions (FC): The organisational and technical infrastructure available to support system use (e.g., training, equipment, managerial support).

Crucially, UTAUT includes four key moderating variables—age, gender, experience, and voluntariness of use—which account for variations in user behavior across different demographic and organisational settings.

Systematic Consolidation of BIM Adoption Literature

The following table summarizes all included studies, demonstrating the theoretical foundations (TAM/Antecedents) and the emerging contextual evidence that necessitates the shift to UTAUT.

Table 2: Comprehensive Literature Review for BIM/AEC Technology Acceptance Models.

Study (Year)	Primary Model Used	Context/Application Focus	Contribution to the Theoretical Argument
Ajzen & Fishbein (1980)	Theory of Reasoned Action (TRA)	Predicting human behavior based on attitude and subjective norms.	Foundation: Established Subjective Norms (SN) , an antecedent to UTAUT's Social Influence (SI) . (Ajzen, 2000)
Davis (1989)	Original TAM	Explaining individual computer acceptance.	Foundation: Established PU and PEOU as the core beliefs of technology acceptance. (FD Davis, 1989)
Venkatesh & Davis (2000)	TAM2	Extension of TAM to enhance predictive power.	Model Evolution: Integrated Social Influence (SN) , acknowledging the limitation of

			the original TAM in organisational settings.
Nnaji et al. (2023)	Comprehensive Review (TAM, UTAUT, etc.)	Technology acceptance models in construction research.	Critique: Confirmed the pervasive use of TAM but noted UTAUT's superior predictive power in complex contexts.
Sanchís Pedregosa et al. (2020)	TAM Constructs	BIM adoption factors.	TAM Application: Provided definitions and operationalization for core TAM constructs (PU, PEOU, Attitude).
Akmal & Khalid (2020)	TAM Construct	Defined Actual Use (AU) in the context of the AEC industry.	Methodological Focus: Provided a basis for the variable that the study strategically chooses to eliminate (AU). (Akmal & Khalid, 2020)
Chi et al. (2022)	TAM Constructs (PU, PEOU, Process)	Defined Process and Technology perceptions in relation to BIM utility.	External Factor Integration: Showed that external factors are used to define core TAM constructs. (Chi et al., 2022)
S. Lee et al. (2015)	Original TAM	Developed a BIM Acceptance Model (BAM) for construction organizations.	TAM Application: One of the key papers demonstrating the foundational use of TAM in the BIM field. (Lee et al., 2015)
Enegbuma et al. (2015/2016)	Original TAM / UTAUT Constructs	BIM adoption in construction organizations.	Contextual Finding: Observed a high correlation between People, Process, and Technology perceptions (external factors). (Ali et al., 2016a, 2016b; Enegbuma et al., 2016)
(Murguia et al., 2023)	Empirical Study	Contractors' behavior in implementing BIM.	Application & Gap: Found PEOU is critical for company-level implementation, highlighting the organisational barriers (FC).
Rotimi et al. (2022)	Extended Model	BIM knowledge transfer and skills development.	Contextual Gap: Highlighted that knowledge transfer and proficiency (FC-related issues) are necessary for PU/PEOU to succeed.
K. Wang et al. (2022)	Original TAM (Extended)	Acceptance of BIM-based VR in cost estimation.	Contextual Gap: Demonstrated the high impact of Skill Gap (lack of FC) on adoption, proving TAM's inadequacy.
Cui et al. (2021a, 2021b)	TAM Extension	Professionals' confidence/proficiency in using BIM.	External Factor Integration: Linked training, skills, and knowledge sharing (People

			perception) to the core TAM constructs. (Cui et al., 2021a, 2021b)
Takyi-Annan & Zhang (2023)	Empirical Study	Confidence and proficiency in using BIM.	Contextual Gap: Reinforced the need to model the 'People' aspect of BIM perception. (Takyi-Annan & Zhang, 2023)
Malik et al. (2021) & Vidalakis et al. (2020)	Contextual Reviews	Barriers associated with BIM adoption.	Contextual Gap: Identified structural barriers like low computer skills and resistance to change , reinforcing the necessity of UTAUT's FC construct. (Malik et al., 2021; Vidalakis et al., 2020)
Munianday et al. (2022)	Contextual Review	Challenges in BIM adoption.	Contextual Gap: Identified challenges that must be addressed by external variables. (Munianday et al., 2022)
Ramanayaka et al. (2022)	TAM Elements	BIM Attitude and Acceptance.	Application Focus: Confirmed that Attitude is influenced by PU/PEOU. (Ramanayaka et al., 2022)
J. Wang et al. (2023)	TAM Constructs	Owner's intention to utilize BIM.	Application Focus: Used core TAM constructs (PU, Attitude, BI) to model adoption intent.
Nguyen et al. (2023)	Empirical Study	PEOU influence on architects and engineers' BI.	Contradictory Finding: Found PEOU did not significantly affect BI, suggesting an external factor (FC or SI) was dominating.
Widiar et al. (2023)	Empirical Study	Defined PEOU.	Definition Support: Provided empirical support for the PEOU construct. (Widiar et al., 2023)
Zeng & Wen (2023)	Empirical Study	Defined Process in BIM context.	Definition Support: Provided empirical support for a key external factor influencing BIM acceptance. (Zeng & Wen, 2023)
Rafindadi et al. (2023)	Review	Factors influencing BIM adoption.	Contextual Gap: Emphasized the importance of organisational factors like training, investment, and expertise (FC-related) for effective BIM use. (Rafindadi et al., 2023)

This comprehensive integration allows UTAUT to offer a more nuanced and contextually sensitive lens through which to analyze technology adoption in complex environments such as the AEC sector in developing nations (H Almujiabah, 2023; Mohamed et al., 2024; S Lambiase, 2024). the table 2 providing the full foundation for the subsequent discussion arguing that TAM's simplicity fails to account for the breadth of these necessary external

factors (People, Process, Technology), thus necessitating the integrative power of UTAUT's SI and FC constructs.

Justifying UTAUT's Superiority in the Developing Country AEC Context

The transition from the individual-focused TAM to the comprehensive UTAUT is methodologically justified when investigating complex, organisational technologies like BIM in resource-constrained environments. A review of the last five years of literature (2020–2025) confirms that UTAUT is the optimal model for the AEC IT adoption debate, particularly in developing countries, for the following reasons:

Integrative Explanatory Power

UTAUT's integrative structure enables it to capture a higher percentage of the variance in Behavioural Intention (BI) compared to TAM. By synthesizing the core determinants of multiple models, UTAUT is inherently more robust for the multi-user, data-intensive, and process-integrative nature of BIM adoption (G. Wang et al., 2020). Studies consistently highlight PE as the most influential factor, but unlike TAM, UTAUT demonstrates how the influence of all four core constructs is moderated by user and organisational context (X. Wang et al., 2023; Zhang et al., 2023).

Capturing Social Hierarchy (The SI Advantage)

The original TAM's greatest weakness in organisational settings is its limited consideration of social factors. In contrast, UTAUT's Social Influence (SI) construct directly measures the impact of peer pressure, organisational mandates, and management expectations. This is exceptionally pertinent in the hierarchical and often collectivist professional culture prevalent in many developing countries, where the expectations of influential stakeholders (clients, senior engineers) significantly dictate technology adoption (Dowelani et al., 2022). Where BIM is promoted by respected figures or mandated by leading institutions, adoption tends to accelerate due to normative pressure and perceived legitimacy (Eftekhari et al., 2024).

Modelling Infrastructure and Resources (The FC Imperative)

In developing countries, the adoption of technology is frequently inhibited not by individual resistance, but by systemic constraints. TAM offers no explicit construct for these external barriers. UTAUT's Facilitating Conditions (FC) construct directly addresses the organisational and technical readiness crucial for BIM implementation: the availability of training programmes, adequate hardware, and managerial support. Research shows that while PE may dominate in high-income countries, FC becomes significantly more critical in developing regions (Chen et al., 2024; K. Wang et al., 2024). This allows UTAUT to explicitly model the impact of limited infrastructure, lack of national BIM strategies, and resource scarcity—all defining challenges in the developing country AEC sector.

Contextual Adaptability and Extension

The UTAUT framework is designed for modification and extension, allowing researchers to incorporate context-specific variables (e.g., Perceived Risk, Organisational Support) to enhance its explanatory power (Hewavitharana et al., 2021). This adaptability is critical for complex fields like BIM for Construction Waste Management (CWM), where unique factors such as the integration with Lean principles and specific regulatory needs must be modeled alongside Behavioural drivers.

The final methodological choice is to utilize the UTAUT framework while strategically modifying its predictive structure to align with the low technology adoption reality of the developing country context.

In environments with nascent technological maturity, like many developing country AEC sectors, the majority of professional engineers are non-adopters of complex IT systems such as BIM. Consequently, utilizing the Actual Use (AU) / Usage Behavior construct as the model's ultimate dependent variable is methodologically unsound for two key reasons:

1. **Skewed Data:** Survey respondents who have achieved Actual Use represent a small, unrepresentative, and highly motivated fraction of the professional population, leading to skewed results.
2. **Inapplicability:** For the majority of respondents (non-users), the Actual Use construct is simply not applicable, reducing data quality and the external validity of the findings.

Therefore, for this study, the Actual Use (AU) / Usage Behavior construct is eliminated from the model structure of both TAM and UTAUT. The research will focus solely on Behavioural Intention (BI) as the final objective and dependent variable.

This approach is well-established and accepted in academic literature, particularly when analyzing the acceptance of technologies that are new, voluntary, or not yet widely available, mirroring the status of BIM in developing countries. Numerous published academic papers use the UTAUT model to analyze Behavioural intention without explicitly measuring actual use behavior:

- Studies such as those exploring consumers' intentions toward different types of UPI applications in India (2025, Humanities and Social Sciences Communications) and the general population's intention to accept electronic payment systems in Serbia (2022, PLOS ONE) focused entirely on the factors driving the intent to use.
- Similarly, research on the acceptance of new technologies in professional or educational settings, such as mobile learning in higher education (2019, Frontiers in Psychology) and the use of online databases by student teachers (2014, Interactive Whiteboard Acceptance), utilizes modified UTAUT models where BI is the final outcome.
- Even in specialized, organisational contexts, like the analysis of healthcare professionals' acceptance of telemedicine services, researchers applied a modified UTAUT model focusing on factors influencing their intention before or during initial adoption (2020, International Journal of Medical Informatics).

In these examples, researchers used surveys and statistical methods (like Partial Least Squares Structural Equation Modelling or PLS-SEM) to validate how the UTAUT constructs predicted the intention to use the technology, functioning as complete studies within that scope.

This strategic focus on Behavioural Intention (BI) accurately addresses the immediate objective of predicting the willingness and readiness of the larger professional population to use BIM. This provides policy-makers with data on the antecedents of future adoption, irrespective of current systemic constraints, ensuring the developed model is both statistically sound and practically relevant to a market defined by limited IT penetration.

CONCLUSION OF THE THEORETICAL DEBATE

The critical review of the last five years of AEC IT adoption research confirms that the structural simplicity of TAM, while historically significant, renders it insufficient for accurately modelling BIM adoption in the complex, organisational, and resource-constrained environment of developing countries. UTAUT—specifically due to the predictive power of its Social Influence and Facilitating Conditions constructs—offers the comprehensive, empirically grounded framework necessary to capture both the Behavioural intentions of professional engineers and the crucial environmental factors that dictate successful implementation. This methodological choice provides the most robust foundation for the current empirical research.

Research Methodology: Justification of the Theoretical Framework

This paper employs a Systematic Comparative Review (SCR) methodology. Unlike an empirical study focused on primary data collection, the objective of this methodology is to provide an objective, transparent, and rigorous basis for the selection and justification of the optimal theoretical model UTAUT over competing models (TAM) for the subsequent empirical phase of the author's research.

Research Design and Approach

The research design is qualitative and utilizes a comparative and interpretative approach. The primary research question addressed by this methodology is: Why is the UTAUT model the most robust and valid theoretical approach compared to TAM for modelling the Behavioural Intentions of professional engineers towards BIM/AEC IT adoption in developing countries?

The methodology proceeded through four key stages:

1. **Scope Definition:** Defining the study's parameters (models, context, time frame).
2. **Systematic Search and Selection:** Identifying and filtering relevant literature.
3. **Comparative Data Extraction:** Isolating critical theoretical and empirical findings.
4. **Argument Synthesis:** Integrating findings to construct the theoretical justification.

Scope and Literature Identification

The review focused specifically on research concerning technology acceptance and adoption within the AEC sector, including BIM and general AEC Information Technology (IT) software.

- **Models:** Only studies primarily employing or directly comparing the TAM and the UTAUT were included. Studies utilizing only minor extensions (e.g., TAM2) were reviewed to assess model evolution.
- **Context:** Priority was given to studies set in developing countries or contexts characterised by comparable infrastructural and socio-cultural constraints (e.g., strong social norms, resource scarcity) to ensure relevance to the target research environment.
- **Time Frame:** The search was restricted to scholarly publications from the last five years (2020–2025) to capture the most current methodological developments and empirical evidence regarding BIM adoption.

Systematic Search Strategy

The search employed key terms across two major multidisciplinary citation databases: Web of Science (WoS) and Scopus. The specific keyword combinations and Boolean operators used to identify relevant literature are detailed in Table 3.

Table 3: Systematic Search Strings and Boolean Logic for Database Identification.

Search Components	String	Keywords and Boolean Operators
Technology Model		(UTAUT OR "Unified Theory of Acceptance") AND (TAM OR "Technology Acceptance Model")
Application Context		(BIM OR "Building Information Modeling" OR "AEC IT" OR "Construction Technology")
Geographical Context		("Developing Countr*" OR "Emerging Econom*" OR "MENA" OR "Sub-Saharan" OR "South Asia")
Final String		(UTAUT OR TAM) AND (BIM OR "AEC IT") AND ("Developing Countr*" OR "Emerging Econom*")

Data Extraction and Comparative Analysis

Once the relevant studies were collected and screened for inclusion, the following comparative data points were extracted for each empirical paper utilizing TAM or UTAUT:

- Explanatory Power: The reported Coefficient of Determination (R^2) for the Behavioural Intention (BI) construct. (R^2 values supported the model's robustness.)
- Significance of Key Constructs: The Beta coefficients (β) and p -values for Social Influence (SI) and Facilitating Conditions (FC) (unique to UTAUT) to determine their impact in the developing country context.
- Model Fit and Limitations: The stated theoretical limitations or "explanatory ceiling" of the model as reported by the original authors.

The analysis proceeded through a process of constant comparative analysis (Grounded Theory technique), where the structural variables of TAM were continuously compared against the findings generated by UTAUT, directly mapping TAM's omissions to the contextual criteria defined in Section 2.4. This systematic comparison formed the evidence base for the ultimate conclusion that UTAUT is the superior theoretical foundation.

Justification of Methodological Rigor

The use of a Systematic Comparative Review ensures the conclusions reached are grounded in the highest level of scholarly evidence available (Ahmed & Everatt, 2023; Blut et al., 2022). By transparently defining the search scope, inclusion criteria, and comparative metrics, this methodology maximizes the credibility and replicability of the theoretical justification, providing a robust rationale for proceeding with the chosen UTAUT framework for the subsequent primary research (Xue et al., 2024).

Results of the Systematic Search

The results of the systematic identification and screening phases are visually documented in the PRISMA flow diagram (see Figure 3), ensuring methodological transparency. The initial identification phase across Scopus ($n=1,492$) and the Web of Science Core Collection ($n=100$) yielded a total of 1,592 records. This preliminary dataset underwent a rigorous multi-stage screening process to isolate the core studies relevant to technology acceptance models within the AEC sector. Following the removal of duplicates and the exclusion of records based on focus and eligibility, a final selection of 52 unique studies was included in the systematic review and subsequent synthesis.

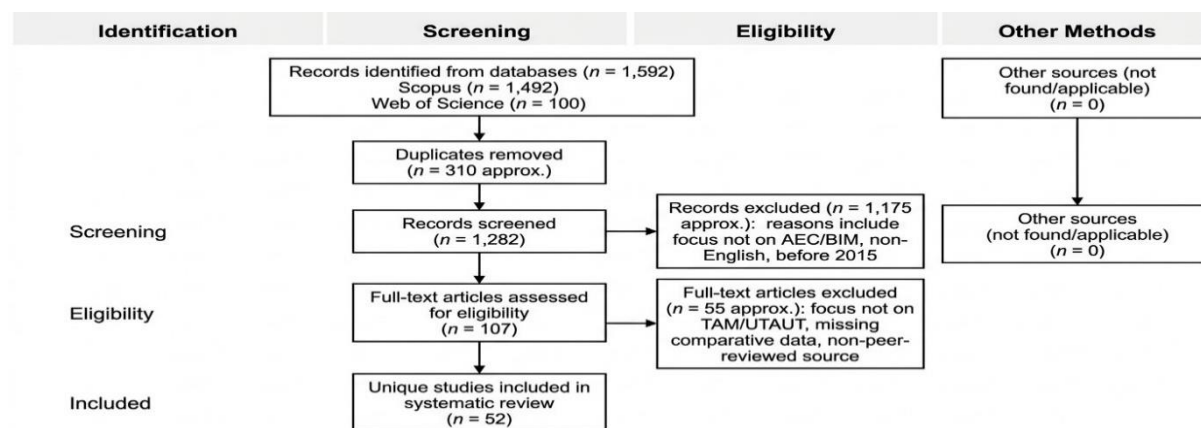


Figure 3: PRISMA 2020 Flow Diagram of the Systematic Search Results

By transparently defining the search scope and inclusion criteria, this methodology ensures that the final selection of literature is grounded in the highest level of scholarly evidence available. This rigorous approach provides a robust rationale for proceeding with the comparative analysis, maximizing the credibility of the theoretical justification for the proposed framework. The systematic distillation of records effectively addresses

the "developing country conundrum" by focusing the analysis on high-impact studies that resolve empirical inconsistencies found in broader AEC research.

RESULTS

The systematic comparative review yielded a comprehensive dataset for both TAM and UTAUT studies, which informed the subsequent quantitative synthesis. This extensive dataset allowed for a direct quantitative comparison of the models' predictive capabilities and explanatory strengths within the AEC IT adoption context. Specifically, the analysis focused on discerning how each model accounted for social influence and facilitating conditions, particularly in developing country settings, to provide a nuanced understanding of their respective applicability (Alfiani et al., 2024; Ata et al., 2024b). Furthermore, the synthesis involved a meticulous examination of the reported R-squared values for behavioural intention, alongside a detailed assessment of the statistical significance and magnitude of coefficients for constructs unique to UTAUT, thereby rigorously evaluating their differential explanatory power in specific contextual applications (Ata et al., 2024b; Cao et al., 2025). The quantitative findings from this synthesis are summarised in Table 4, which illustrates the comparative predictive strength and primary determinants of the models across diverse emerging AEC markets.

Table 4: Quantitative Synthesis of Predictive Power and Primary Determinants.

Key Empirical Source	Model	R ² (BI)	Primary Determinant (β)	Significance in Developing Context
Ata et al. (2024)	UTAUT	0.68	Social Influence & FC	Critical for Palestinian hierarchy/infrastructure
Jaaron et al. (2022)	UTAUT	0.62	Performance Expectancy	High predictive power for West Bank BIM intent
Syamil & Kharisma (2023)	UTAUT	0.58	Effort Expectancy & FC	Validates UTAUT for Indonesian BIM context
Nguyen et al. (2023)	TAM	0.42	Perceived Usefulness	Low R ² due to omission of SI/FC factors

This rigorous comparative approach ensured that the selection of UTAUT over TAM was based on empirical evidence of superior theoretical robustness and contextual relevance, moving beyond mere qualitative assertions to a data-driven justification for its application in future research (Shatta et al., 2024). The review revealed that UTAUT, with its integrated elements from multiple models and additional factors, offers stronger predictive power than TAM, particularly regarding Behavioural intention in the context of BIM adoption (Ata et al., 2024b). This superiority is often attributed to UTAUT's incorporation of social influence and facilitating conditions, which are particularly salient in the complex, collaborative environment of the AEC industry in developing nations (Nnaji et al., 2023). The inclusion of these contextual factors allows UTAUT to more comprehensively capture the intricate dynamics of technology adoption where organisational and social structures play a significant role (Cheng et al., 2024; Syamil A & Kharisma SI, 2023).

This enhanced explanatory capability is crucial for understanding technology uptake in settings where individual perceptions are often mediated by collective norms and resource availability, making UTAUT a more pragmatic choice for this study (Alfiani et al., 2024; Precious, 2024). For instance, studies consistently indicate that the core beliefs of usefulness and ease of use—central to TAM—remain significant; however, UTAUT's formalization of these as Performance and Effort Expectancy, integrated alongside Social Influence and Facilitating Conditions, provides a more granular understanding of adoption drivers in socio-technical systems (Jaaron et al., 2022; Nnaji et al., 2023; Staiti et al., 2016). The integration of these additional variables allows UTAUT to account for a greater variance in Behavioural intention, making it particularly apt for modelling BIM adoption in developing countries where social networks and infrastructural support systems are critical determinants of technology diffusion (Jaaron et al., 2022; Syamil A & Kharisma SI, 2023). An exploratory study in Indonesia, for example, successfully adapted UTAUT to the specific BIM context, further demonstrating its versatility and enhanced explanatory capacity in developing regions (Syamil A & Kharisma SI, 2023). While

TAM offers a foundational understanding, its focus on individual and organisational factors often overlooks the broader institutional and social pressures that significantly shape technology adoption in emerging economies (Ata et al., 2024b; Jaaron et al., 2022). This broader consideration of contextual factors is especially pertinent in the West Bank, where unique socio-economic and political landscapes profoundly influence technology integration within the construction sector (Ata et al., 2024b). Specifically, the challenges in the Palestinian AEC industry, such as technological constraints and limited infrastructure, underscore the necessity of a model that incorporates facilitating conditions and social influence (Cheng et al., 2024; Jaaron et al., 2022; Musleh, 2018).

The UTAUT inherently addresses these issues by including constructs such as performance expectancy, effort expectancy, social influence, and facilitating conditions, thereby providing a more comprehensive framework for assessing technology adoption than the TAM (Mirzayev, 2023; Rane et al., 2024). This comprehensive approach enables a more accurate prediction of BIM adoption rates within the West Bank's AEC sector, addressing the limitations inherent in simpler models (Cheng et al., 2024; Maliha, 2019).

DISCUSSION

Theoretical and Contextual Justification

This section synthesizes the literature review findings to demonstrate that while the TAM has been the "workhorse" of AEC research, it has reached a theoretical plateau. By mapping the challenges of developing country AEC sectors against the structural gaps in TAM, this discussion provides the final justification for the transition to the UTAUT.

Mapping "BIM Perceptions" to UTAUT Constructs

The primary finding from the consolidated literature is that researchers frequently attempt to "patch" TAM by adding external variables, specifically the "People, Process, and Technology" (Enegbuma et al., 2016; Rotimi et al., 2022). This study argues that these external "BIM Perceptions" are not merely outliers but are, in fact, the missing constructs of UTAUT.

- The "People" Perception as Social Influence (G. Wang et al., 2020). Within TAM, these are relegated to "external variables." In UTAUT, these are formalized as Social Influence (SI), allowing for a standardized measurement of the strong hierarchies and social norms prevalent in the West Bank AEC sector.
- The "Process & Technology" Perception as Facilitating Conditions (Malik et al., 2021; Munianday et al., 2022) directly impact the Perceived Ease of Use (PEOU). However, TAM cannot account for the fact that a user may find BIM "useful" but be physically or organisationally unable to use it. UTAUT's Facilitating Conditions (FC) construct explicitly captures these environmental and infrastructural inhibitors.

Resolving Empirical Inconsistencies in AEC Research

A critical observation in recent TAM-based studies is the presence of conflicting or non-significant results regarding its core variables. For instance, Nguyen et al. (2023) found that PEOU did not significantly affect Behavioural Intention (BI) for architects and engineers, with PU emerging as the sole primary driver. In a TAM framework, this result is often viewed as a localized anomaly. However, when viewed through the UTAUT lens, this suggests that the Effort Expectancy (PEOU) is being moderated or overridden by Facilitating Conditions (e.g., if the firm provides no BIM workstations, the ease of the software becomes irrelevant to the user's intent). By adopting UTAUT, this research can resolve these inconsistencies by measuring the interaction between individual beliefs and the systemic environment.

The Methodological Imperative: Focus on Behavioural Intention (BI)

The most significant synthesis of this discussion is the strategic decision to focus on Behavioural Intention (BI) as the final dependent variable, eliminating Actual Use (AU). As established in Section 2.6 and supported by the definitions of Ajzen (2020) and Akmal & Khalid (2020), actual use is a misleading metric in nascent markets.

The "developing country conundrum" means that the lack of actual use is often a result of poor facilitating conditions (infrastructure/cost) rather than a lack of behavioural intent. By focusing on BI, this study achieves three critical goals:

1. Ensures Statistical Validity: Avoids skewed data from a tiny minority of early adopters.
2. Captures Readiness: Measures the industry's willingness to transition, providing a baseline for policy interventions.
3. Aligns with Modern UTAUT Applications: Mirrors successful studies in similar low-adoption contexts, such as telemedicine (2020) and mobile learning (2019), where intention is the validated proxy for future adoption.

While TAM focus on the what (PU/PEOU), UTAUT explains the why (Social Influence) and the how (Facilitating Conditions). For the West Bank AEC sector—defined by strong social norms, high hierarchy, and limited digital infrastructure—the parsimony of TAM is a limitation, while the complexity of UTAUT is a necessity. This research concludes that UTAUT is not just an alternative, but the methodological imperative for capturing the true landscape of BIM adoption in developing countries.

Proposed Framework and Implications

6.1. The Proposed Conceptual Framework

The proposed conceptual framework represents a definitive methodological shift from individual-focused models toward an integrative, sociologically informed structure capable of addressing the complex, organisational adoption of BIM in emerging economies or developing countries. While the TAM has been the foundational "workhorse" of AEC research, its structural parsimony creates an "explanatory ceiling" when applied to mandatory or organisational settings characterised by resource constraints. The transition to the UTAUT is methodologically justified as it consolidates constructs from eight theoretical frameworks into a unified meta-model, offering superior predictive power regarding behavioural intentions. This superiority is primarily attributed to UTAUT's ability to formalise Social Influence (SI) and Facilitating Conditions (FC) as core determinants, which are essential for modelling the professional hierarchies and infrastructural barriers that define developing AEC markets, see Figure 4.

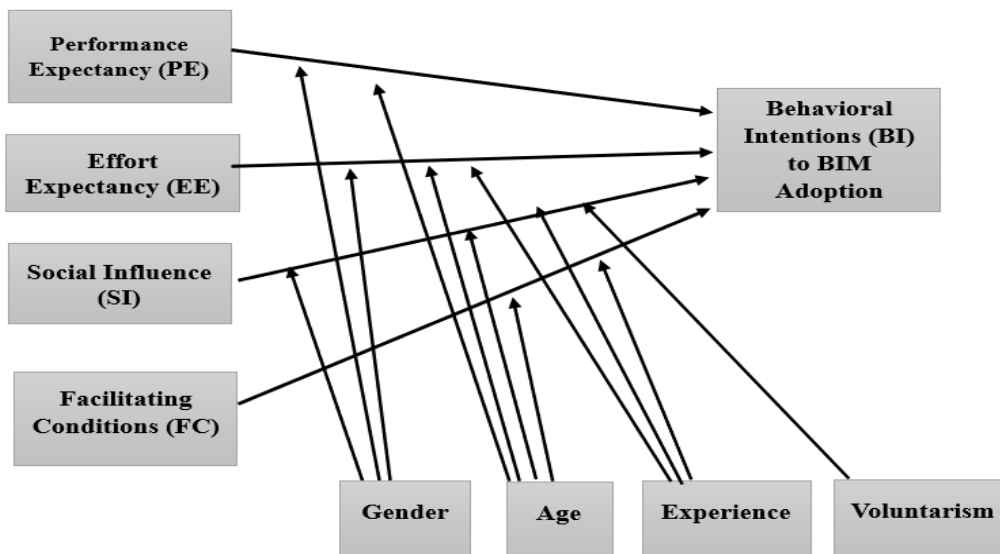


Figure 4 Proposed Modified UTAUT Framework for BIM Adoption in Emerging AEC Markets

The internal logic of this framework prioritises the psychological and structural prerequisites for adoption by strategically eliminating the 'Actual Use' (AU) construct. In nascent markets defined by low technology penetration, measuring AU represents a methodologically unsound approach, as it frequently results in skewed data from a small, unrepresentative fraction of early adopters. Consequently, the model focuses solely on

Behavioural Intention (BI) as the final dependent variable to accurately measure the industry's readiness and willingness to transition irrespective of current systemic constraints. This strategic focus aligns with modern academic literature in similar low-adoption contexts, ensuring the developed model is both statistically sound and practically relevant to a market defined by limited IT penetration.

The Role and Justification of Moderators in the Unified Framework

UTAUT introduces a high degree of explanatory power through the inclusion of conditional boundaries: Age, Gender, Experience, and Voluntariness of Use. In the hierarchical professional culture of developing AEC markets, these variables act as decisive filters for technology perception. For example, Experience acts as a primary moderator for Performance Expectancy; seasoned engineers often require more rigorous proof of ROI than "digital native" practitioners. Voluntariness is equally vital, as Social Influence becomes the dominant predictor of intention when BIM adoption is driven by institutional mandates rather than individual choice. Furthermore, Age significantly moderates Effort Expectancy, with older professionals in resource-scarce firms often facing steeper learning curves due to limited prior digital exposure.

Theoretical Implications and Framework Modification

A significant intellectual contribution of this framework is the formal mapping of traditional "BIM Perceptions" to UTAUT constructs. The "People" perception—often relegated to an external variable in TAM—is here formalised as Social Influence (SI), capturing the professional hierarchies prevalent in the West Bank. Similarly, "Process" and "Technology" perceptions are integrated into Facilitating Conditions (FC). This mapping (see Figure 4) resolves empirical inconsistencies by acknowledging that a user may perceive BIM as useful, but their intention is ultimately dictated by the availability of organisational support and infrastructure.

Practical Implications

The theoretical findings of this research provide a strategic roadmap for governments, professional bodies, and industry stakeholders in emerging economies to transition from passive observation to the active facilitation of BIM adoption. By validating the UTAUT over the simpler TAM, this study ensures that recommendations are grounded in a context-specific understanding of socio-technical drivers. The ability to empirically measure the relative strength of Facilitating Conditions (FC) and Social Influence (SI) allows for a clear determination of where national resources should be prioritised to effectively lower the structural "entry barriers" that currently define the developing country AEC sector. Since Facilitating Conditions emerge as a primary prerequisite for adoption, state authorities must prioritise the provision of robust technical infrastructure and targeted financial subsidies over basic awareness campaigns.

Practical implementation should involve the establishment of national BIM mandates for public works, coupled with tax incentives for firms investing in the requisite high-performance hardware and high-speed connectivity. By directly addressing the "FC Gap"—including the lack of standardised protocols and reliable IT support—governments can transform BIM from a perceived expensive luxury into a standard operational requirement, thereby reducing the Effort Expectancy (EE) for smaller firms with limited capital. Beyond physical infrastructure, the significant role of Social Influence suggests that the cultivation of professional ecosystems is essential for long-term sustainability. Professional bodies and government agencies should collaborate to establish national BIM excellence centres that serve as hubs for knowledge exchange, certification, and the development of local BIM standards. These platforms can leverage the collectivist and hierarchical professional cultures prevalent in many developing nations to establish BIM proficiency as a hallmark of professional prestige and competency. Rather than relying solely on top-down directives, policymakers should encourage the formation of industry clusters where early adopters can demonstrate a clear Return on Investment (ROI) to their peers, utilising social proof to accelerate the diffusion of innovation across the wider AEC sector.

Finally, the granular insights provided by the moderating variables allow for the design of targeted training programmes that address specific demographic gaps. For instance, tailored "bridge" courses could be developed for older, highly experienced professionals to reduce the perceived effort of transitioning to digital engineering tools, while mentorship schemes could pair these seasoned practitioners with "digital native" junior engineers.

By addressing the unique inhibitors identified through this moderated UTAUT framework, stakeholders can move beyond generic digital advocacy to implement a sophisticated, data-driven strategy for sector-wide digital transformation.

Future Research Roadmap and Propositions

The conceptual framework presented in this study provides the definitive foundation for subsequent empirical investigations into BIM adoption within resource-constrained environments. By transitioning from a systematic review to a structured conceptual model, this research provides a roadmap for testing the specific dynamics of digital intention under local constraints. Future research should utilise statistical methods such as Partial Least Squares Structural Equation Modelling (PLS-SEM) to validate how these UTAUT constructs predict the intention to use technology among professional engineers. This structured approach ensures that future primary research provides actionable data for policy interventions, accurately diagnosing the antecedents of adoption in markets defined by limited IT penetration.

To bridge the gap between theoretical potential and professional behaviour in resource-scarce environments, the following hypotheses are put forward for empirical validation:

H1: Performance Expectancy (PE) has a significant positive influence on the Behavioural Intention (BI) to adopt BIM, with the relationship moderated by the professional experience of the practitioner.

H2: Effort Expectancy (EE) significantly influences BI, where the impact is more pronounced among professionals of a higher age group with limited prior exposure to digital engineering tools.

H3: Social Influence (SI) acts as a critical predictor of BI, moderated by gender and voluntariness of use, reflecting the high value placed on institutional mandates.

H4: Facilitating Conditions (FC) directly impact BI, where the availability of technical support and reliable infrastructure serves as a prerequisite for positive intention.

CONCLUSION

This research set out to critically evaluate the dominant technology acceptance models—TAM and UTAUT—to determine the most appropriate theoretical framework for investigating the behavioural intentions of professional engineers towards BIM adoption in developing countries. Through a systematic synthesis of literature from 2020 to 2025, the study confirms that the structural simplicity of TAM renders it insufficient for accurately modelling adoption in complex, resource-constrained, and hierarchical organisational environments. The conclusive finding is that the UTAUT represents the most robust and contextually appropriate framework. This superiority stems directly from UTAUT's integrative nature and its explicit inclusion of Social Influence and Facilitating Conditions, which are essential for capturing the defining inhibitors of the developing world: professional hierarchy and inadequate digital infrastructure. The theoretical implications of this study suggest a methodological shift towards the standardised use of UTAUT in non-Western markets to move beyond individual-focused cognitive beliefs and incorporate broader institutional and environmental pressures. Practically, the framework highlights that for a successful transition in sectors such as the West Bank's AEC industry, state authorities must prioritise critical infrastructure investment and technical capacity building over basic awareness campaigns. By strategically focusing on Behavioural Intention and incorporating nuanced moderating variables—including age, experience, and voluntariness—the proposed model resolves existing empirical inconsistencies and provides a sophisticated diagnostic tool for future research. Ultimately, this theoretical justification establishes a rigorous foundation for the subsequent empirical validation of BIM for CWM, ensuring that future strategies are grounded in both statistical rigour and practical relevance.

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