



**THE RELATIONSHIP BETWEEN
TECHNOLOGICAL, ORGANIZATIONAL, AND
ENVIRONMENTAL FACTORS AND BUILDING
INFORMATION MODELING ADOPTION IN THE
LIBYAN CONSTRUCTION SECTOR: THE
MODERATING ROLE OF CORPORATE
CULTURE**

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THESIS APPROVAL PAGE

I certify that in my opinion the thesis submitted by Ismail Mohamed HILAN titled “The Relationship Between Technological, Organizational, and Environmental Factors and Building Information Modeling Adoption in the Libyan Construction Sector: The Moderating Role of Corporate Culture” is fully adequate in scope and in quality as a thesis for the degree of PhD.

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The degree of PhD by the thesis submitted is approved by the Administrative Board of the Institute of Graduate Programs, Karabuk University.

Assoc. Prof. Dr. Zeynep ÖZCAN
Director of the Institute of Graduate Programs

DECLARATION

I hereby declare that this thesis is the result of my own work and all information included has been obtained and expounded in accordance with the academic rules and ethical policy specified by the institute. Besides, I declare that all the statements, results, materials, not original to this thesis have been cited and referenced literally.

Without being bound by a particular time, I accept all moral and legal consequences of any detection contrary to the aforementioned statement.

Name Surname: Ismail Mohamed HILAN

Signature :

FOREWORD

This dissertation represents the culmination of sustained academic effort and intellectual commitment devoted to understanding the factors influencing Building Information Modeling adoption in the Libyan construction sector. The study was developed in response to the growing importance of digital transformation in the construction industry and the need to explain how technological, organizational, and environmental factors, together with institutional pressures and corporate culture, shape the adoption of BIM in a developing-country context. I would like to express my sincere gratitude to my supervisor for his valuable guidance, continuous support, and constructive academic feedback throughout the development of this dissertation. His supervision played an important role in strengthening the theoretical foundation, improving the methodological rigor, and enhancing the overall academic quality of this research. I also extend my appreciation to the faculty members of the relevant academic department at Karabük University for their support, encouragement, and scholarly contributions throughout my doctoral journey. Their academic insights and guidance have been greatly valuable in the completion of this dissertation. My sincere thanks are also extended to all professionals and respondents in the Libyan construction sector who participated in the survey and contributed their time and perspectives to this study. Without their cooperation, this research would not have been possible. Finally, I would like to acknowledge with deep appreciation all those who supported me throughout this academic journey. Their encouragement, patience, and confidence provided a constant source of motivation in completing this work.

ABSTRACT

This study examines the relationships between technological, organizational, and environmental factors and Building Information Modeling adoption in the Libyan construction sector. The study is grounded in Technology, Organization, and Environment framework and Institutional Theory, and it investigates the extent to which Complexity, Relative Advantages, Compatibility, Top Management Support, Organizational Readiness, Mimetic Pressures, Coercive Pressures, and Normative Pressures are statistically associated with organizational BIM adoption. In addition, Corporate Culture is examined as a moderating variable in the relationship between Normative Pressures and BIM adoption. The study adopted a quantitative cross-sectional research design and used a structured questionnaire to collect data from professionals working in the Libyan construction sector. The collected data were analyzed using Partial Least Squares Structural Equation Modelling. The analytical procedure included the assessment of the measurement model and the structural model before hypothesis testing. The findings showed that all the hypothesized direct relationships with BIM adoption were positive and statistically significant. Normative Pressures recorded the strongest direct relationship, followed by Relative Advantages, Mimetic Pressures, Coercive Pressures, Top Management Support, Complexity, Compatibility, and Organizational Readiness. The results also showed that Corporate Culture positively and significantly moderated the relationship between Normative Pressures and BIM adoption. These findings indicate that organizational BIM adoption in the Libyan construction sector is associated with a combination of institutional legitimacy pressures, perceived technological value, internal organizational support, and a supportive internal cultural condition. The study contributes to the BIM adoption literature by supporting the value of integrating the TOE framework with Institutional Theory in an underexplored construction context. It also provides practical implications for managers, policymakers, and professional bodies seeking to strengthen the organizational uptake and continuing institutionalization of BIM in Libya.

Keywords: Building Information Modeling (BIM); Technology-Organization-Environment (TOE) Framework; Corporate Culture; BIM Adoption; Construction Industry; Digital Transformation; Libya; Technological Factors; Organizational Readiness; Environmental Pressures; Top Management Support; Innovation; Developing Countries; Quantitative Research; SmartPLS Analysis.

ÖZ

Bu çalışma, Libya inşaat sektöründe teknolojik, örgütsel ve çevresel faktörler ile Yapı Bilgi Modellemesi, Building Information Modeling, BIM benimsenmesi arasındaki ilişkileri incelemektedir. Çalışma, Teknoloji, Organizasyon ve Çevre, Technology, Organization, and Environment, TOE çerçevesi ile Kurumsal Teoriye dayanmaktadır. Ayrıca, Karmaşıklık, Görelî Avantajlar, Uyumluluk, Üst Yönetim Desteği, Örgütsel Hazırlık, Taklitçi Baskılar, Zorlayıcı Baskılar ve Normatif Baskıların örgütsel BIM benimsenmesi ile istatistiksel olarak ne ölçüde ilişkili olduğu araştırılmaktadır. Buna ek olarak, Kurumsal Kültür, Normatif Baskılar ile BIM benimsenmesi arasındaki ilişkide düzenleyici bir değişken olarak incelenmiştir. Çalışmada nicel kesitsel araştırma deseni benimsenmiş ve Libya inşaat sektöründe çalışan profesyonellerden veri toplamak için yapılandırılmış bir anket kullanılmıştır. Toplanan veriler, Kısmi En Küçük Kareler Yapısal Eşitlik Modellemesi, Partial Least Squares Structural Equation Modelling, yöntemi ile analiz edilmiştir. Analitik süreç, hipotez testine geçmeden önce ölçüm modelinin ve yapısal modelin değerlendirilmesini içermiştir. Bulgular, BIM benimsenmesi ile ilgili varsayılan tüm doğrudan ilişkilerin pozitif ve istatistiksel olarak anlamlı olduğunu göstermiştir. Normatif Baskılar en güçlü doğrudan ilişkiyi göstermiş, bunu sırasıyla Görelî Avantajlar, Taklitçi Baskılar, Zorlayıcı Baskılar, Üst Yönetim Desteği, Karmaşıklık, Uyumluluk ve Örgütsel Hazırlık izlemiştir. Sonuçlar ayrıca, Kurumsal Kültürün Normatif Baskılar ile BIM benimsenmesi arasındaki ilişkiyi pozitif ve anlamlı biçimde düzenlediğini göstermiştir. Bu bulgular, Libya inşaat sektöründe örgütsel BIM benimsenmesinin kurumsal meşruiyet baskıları, algılanan teknolojik değer, iç örgütsel destek ve destekleyici bir iç kültürel koşulun birleşimi ile ilişkili olduğunu göstermektedir. Çalışma, yeterince araştırılmamış bir inşaat bağlamında TOE çerçevesi ile Kurumsal Teorinin bütünleştirilmesinin değerini destekleyerek BIM benimsenmesi literatürüne katkı sunmaktadır. Ayrıca, Libya'da BIM'in örgütsel düzeyde benimsenmesini ve devam eden kurumsallaşmasını güçlendirmeyi amaçlayan yöneticiler, politika yapımcılar ve meslek kuruluşları için pratik çıkarımlar sağlamaktadır.

Anahtar Kelimeler: Yapı Bilgi Modellemesi (BIM); Teknoloji-Organizasyon-Çevre (TOE) Çerçevesi; Kurumsal Kültür; BIM Benimsenmesi; İnşaat Sektörü; Dijital Dönüşüm; Libya; Teknolojik Faktörler; Örgütsel Hazırlık; Çevresel Baskılar; Üst Yönetim Desteği; Yenilik; Gelişmekte Olan Ülkeler; Nicel Araştırma; SmartPLS Analizi.

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ARŞİV KAYIT BİLGİLERİ

Tezin Adı	Teknolojik, Örgütsel ve Çevresel Faktörler ile Libya İnşaat Sektöründe Yapı Bilgi Modellemesi Benimsenmesi Arasındaki İlişki: Kurumsal Kültürün Düzenleyici Rolü
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ABBREVIATIONS

BIM: Building Information Modeling

CC: Corporate Culture

ECP: Coercive Pressures

EMP: Mimetic Pressures

ENP: Normative Pressures

OOR: Organizational Readiness

OTMS: Top Management Support

PLS-SEM: Partial Least Squares Structural Equation Modeling

TCO: Complexity

TCOM: Compatibility

TOE: Technology, Organization, and Environment

TRA: Relative Advantages

SUBJECT OF THE RESEARCH

The subject of this research is the examination of the relationships between technological, organizational, and environmental factors and Building Information Modeling adoption in the Libyan construction sector. The study focuses on how Complexity, Relative Advantages, Compatibility, Top Management Support, Organizational Readiness, Mimetic Pressures, Coercive Pressures, and Normative Pressures are statistically associated with organizational BIM adoption. In addition, the study examines whether Corporate Culture moderates the relationship between Normative Pressures and BIM adoption. The subject of the research is positioned within the broader field of construction management, innovation adoption, digital transformation, and organizational response to institutional pressures in developing construction environments.

PURPOSE AND IMPORTANCE OF THE RESEARCH

The primary purpose of this research is to examine and explain the relationships between technological, organizational, and environmental factors and Building Information Modeling adoption in the Libyan construction sector by using an integrated theoretical model based on the Technology, Organization, and Environment framework and Institutional Theory. More specifically, the study seeks to assess whether Complexity, Relative Advantages, Compatibility, Top Management Support, Organizational Readiness, Mimetic Pressures, Coercive Pressures, and Normative Pressures are statistically associated with BIM adoption, and whether Corporate Culture moderates the relationship between Normative Pressures and BIM adoption. The study is therefore designed to provide an empirically grounded explanation of organizational BIM adoption in an underexplored construction context rather than to claim strict temporal causality in an experimental sense. This purpose is methodologically consistent with the cross-sectional survey design and the PLS-SEM analytical approach adopted in the study.

The importance of the research lies in both its theoretical and practical value. Theoretically, the study contributes to the BIM adoption literature by integrating the TOE framework with Institutional Theory in a single organizational-level model and by treating Corporate Culture as a focused moderating variable rather than as a broad and weakly specified background factor. Practically, the study provides evidence that can help policymakers, construction firms, consultants, project leaders, and professional bodies understand how BIM uptake may be strengthened in Libya through a combination of technological manageability, organizational support, environmental legitimacy, and supportive internal culture. The importance of the research is especially strong because Libya remains an underexplored

context in BIM research despite its practical need for stronger coordination, digital information management, and more effective project delivery in the construction sector.

METHOD OF THE RESEARCH

This research employed a quantitative research method based on a cross-sectional survey design. Data were collected through a structured questionnaire distributed to knowledgeable participants working in or closely with construction-related organizations in the Libyan construction sector. The questionnaire items were developed on the basis of prior literature and aligned with the study constructs. The study measured the direct explanatory variables of Complexity, Relative Advantages, Compatibility, Top Management Support, Organizational Readiness, Mimetic Pressures, Coercive Pressures, and Normative Pressures, together with the moderating variable of Corporate Culture and the dependent variable of Building Information Modeling adoption.

The collected data were analyzed using Partial Least Squares Structural Equation Modelling, PLS-SEM. The analytical process included preliminary data screening, descriptive analysis, measurement-model assessment, and structural-model assessment before hypothesis testing. Reliability and validity were examined prior to the assessment of structural relationships, and bootstrapping procedures were used to evaluate the statistical significance of the direct and moderating relationships. This methodological approach was appropriate because the study sought to examine relationships among multiple latent constructs in an organizational adoption model within an underexplored empirical context.

HYPOTHESIS OF THE RESEARCH / RESEARCH PROBLEM

Despite the widely recognized value of Building Information Modeling in improving coordination, information integration, visualization, and project decision-making, BIM adoption in the Libyan construction sector remains limited, uneven, and insufficiently institutionalized at the organizational level. Existing evidence indicates that many Libyan construction organizations continue to rely heavily on conventional work methods, while BIM maturity, practical experience, and implementation readiness remain weak. At the same time, the wider literature still does not provide a sufficiently integrated and context-sensitive explanation of how technological, organizational, and environmental conditions are associated with BIM adoption in Libya. This creates an unresolved theoretical and practical problem that justifies the present study.

The study therefore addresses the problem that BIM adoption in Libya cannot be explained adequately through isolated technical barriers or benefits alone. Rather, it must be examined through a broader organizational and institutional perspective that considers technological evaluation, internal organizational support, external environmental pressures, and the conditional role of Corporate Culture. On this basis, the study tests a set of hypotheses concerning the direct relationships between the specified technological, organizational, and environmental variables and BIM adoption, as well as the moderating role of Corporate Culture in the relationship between Normative Pressures and BIM adoption. The problem of the research is thus not simply whether BIM is useful, but why its recognized value has not yet translated into stronger organizational adoption in the Libyan construction sector.

SCOPE AND LIMITATIONS / DIFFICULTIES

The present study is limited to the Libyan construction sector and focuses specifically on the organizational adoption of Building Information Modeling from technological, organizational, and environmental perspectives, together with the moderating role of Corporate Culture. The conceptual scope of the study is intentionally restricted to the variables included in the final model, namely Complexity, Relative Advantages, Compatibility, Top Management Support, Organizational Readiness, Mimetic Pressures, Coercive Pressures, Normative Pressures, Corporate Culture, and BIM adoption. It does not attempt to cover all possible determinants of BIM adoption, nor does it extend to post-adoption outcomes such as project performance, lifecycle efficiency, or implementation maturity across all projects. The study is therefore focused on explaining organizational BIM adoption itself rather than the full range of consequences that may follow after adoption has occurred.

The study is also limited methodologically. It adopts a quantitative cross-sectional design, which means that the data were collected at one point in time and therefore do not capture how BIM adoption may evolve across different stages of organizational change or institutional development. In addition, the study is based on self-reported questionnaire responses, which means that the empirical evidence reflects informed respondent perceptions rather than audited organizational records or direct observation of BIM practice. Because the study relies on a single survey instrument, some degree of common method bias may also be present, and the findings should therefore be interpreted with appropriate methodological caution. Furthermore, the study employed purposive sampling, which enhances relevance and respondent suitability but does not provide strict census-level representativeness for the entire Libyan construction sector.

The research also faced practical difficulties related to access to respondents, the uneven level of BIM familiarity across the sector, and the challenge of collecting sufficiently usable responses in a context where BIM is not yet fully institutionalized in professional practice. Nevertheless, the study still provides meaningful empirical evidence on BIM adoption in an underexplored national context and offers a theoretically grounded basis for future research on digital transformation and organizational innovation in construction management.

1. CHAPTER ONE: INTRODUCTION

1.1. Research Background

Building Information Modeling has evolved from a narrow model-based representation of buildings into a broader information-centered, process-oriented, and lifecycle-based approach to managing design, coordination, delivery, and asset information in the construction industry (Succar, 2009; Borkowski, 2023; Chowdhury et al., 2024). In the contemporary literature, BIM is no longer treated adequately as a software package or a three-dimensional drafting aid alone. Rather, it is increasingly understood as a socio-technical and organizational innovation that restructures how information is created, exchanged, and used across the architecture, engineering, construction, and operations domain (Succar, 2009; Borkowski, 2023). This broader understanding is important because it shifts scholarly attention from isolated software use toward organizational adoption, implementation capacity, inter-organizational coordination, and institutional support (Chowdhury et al., 2024). In other words, BIM matters not only because it digitizes information, but because it changes the logic of project collaboration and information governance in construction practice (Succar, 2009; Chowdhury et al., 2024).

Although BIM has gained international recognition, its diffusion has remained highly uneven across countries and industries (Adekunle et al., 2021; Chowdhury et al., 2024). Research on BIM in developing countries shows that diffusion is still incomplete and that many developing construction environments remain at an early stage of adoption (Adekunle et al., 2021). This matters because the construction industry has historically been slower than other sectors in adopting new tools, techniques, and integrated digital work practices, especially where adoption requires skills, capital investment, and coordinated change across multiple actors (Adekunle et al., 2021; El Hajj et al., 2023). As a result, the global rise of BIM has not produced a uniform adoption trajectory. Instead, BIM has spread through differentiated pathways associated with varying levels of technological readiness, organizational capacity, professional maturity, and institutional support (Adekunle et al., 2021; Chowdhury et al., 2024).

This unevenness becomes more visible when attention shifts from developed construction environments to developing and transitional ones. Studies of BIM diffusion in developing countries indicate that adoption is frequently constrained by limited expertise, weak infrastructure, insufficient investment, and fragmented implementation efforts (Adekunle et al., 2021). Research focused on the Middle East and North Africa likewise shows that BIM

adoption barriers in the region are not merely technical. They include structural, human, organizational, and institutional limitations, and they vary in intensity according to the maturity of the local construction environment (El Hajj et al., 2023). This is especially important for the present study because Libya belongs to a regional and developmental setting in which BIM diffusion cannot be explained through technological variables alone. Rather, the background literature suggests that BIM adoption in such contexts must be interpreted as a combined technological, organizational, and environmental process (Adekunle et al., 2021; El Hajj et al., 2023).

Within this broader pattern, Libya presents a particularly important context. Available Libya-specific evidence indicates that BIM adoption remains weakly embedded in organizational practice and that practical implementation is still limited (Elghdhan et al., 2023; Solla et al., 2025). A study of Libyan construction firms found that BIM adoption is associated with technological, organizational, and environmental conditions at the organizational level, which shows that BIM in Libya cannot be understood as a purely technical issue (Elghdhan et al., 2023). Additional Libya-based evidence on BIM-enabled cost estimation reports that conventional methods remain inefficient, manual, and vulnerable to human error, while BIM experience in many firms is still very limited (Solla et al., 2025). Taken together, these findings suggest that the Libyan construction sector has not yet reached a stage at which BIM can be treated as a routine organizational practice (Elghdhan et al., 2023; Solla et al., 2025).

The relevance of the Libyan case is further strengthened by the institutional and economic environment in which the construction sector operates. Libya continues to face political uncertainty, fragmented institutions, and significant capacity constraints, while international assessments have emphasized the need for better coordination, stronger budgeting discipline, and more effective institutional capacity (International Monetary Fund, 2024). In such an environment, digital systems that improve information quality, coordination, and control should carry particular importance for construction management (International Monetary Fund, 2024). Yet the existence of practical need does not automatically generate adoption. Rather, adoption depends on whether firms perceive BIM as manageable and useful, whether they possess internal readiness and leadership support, and whether the external environment generates pressures and legitimacy signals strong enough to encourage organizational movement toward BIM (Elghdhan et al., 2023; Tavallaei et al., 2022).

For that reason, the study present leads naturally to a multi-dimensional explanatory model. From a technological perspective, organizations are likely to evaluate BIM in terms of its complexity, its relative advantages over conventional methods, and its compatibility with existing routines and systems (Elghdhan et al., 2023). From an organizational perspective, adoption is likely to depend on top management support and on the organization's readiness to implement BIM in practice (Elghdhan et al., 2023; Tavallaei et al., 2022). From an environmental perspective, adoption is likely to be associated with mimetic, coercive, and normative pressures arising from competition, dependency, regulation, and professional legitimacy (DiMaggio & Powell, 1983; Tavallaei et al., 2022). This multi-dimensional view is academically justified because recent BIM scholarship has moved away from narrow single-factor accounts and has increasingly emphasized the need for more holistic explanations of adoption in organizational settings (Chowdhury et al., 2024).

Institutional research on BIM adoption shows that not all external pressures operate in the same way and that normative pressure can be especially influential because it works through professional legitimacy, accepted standards, and the growing expectation that BIM represents contemporary and appropriate practice in the sector (DiMaggio & Powell, 1983; Tavallaei et al., 2022). This is especially relevant for the present study because such pressures do not affect all firms uniformly. Their effect may depend on how organizations interpret externally generated expectations through internal values and shared norms (Alankarage et al., 2023). In this regard, the background literature on BIM-related organizational culture becomes highly relevant. Recent systematic review evidence identifies organizational and professional culture change as an underdeveloped but essential area in BIM research, which suggests that culture is not peripheral to BIM adoption but part of the internal process through which innovation is accepted, resisted, or normalized (Alankarage et al., 2023).

This is the point at which the study present reaches its most precise formulation. The study does not treat Corporate Culture as a broad moderator of all relationships in the model. Such a claim would be conceptually weak. Instead, the background literature supports a narrower and more defensible position, namely that Corporate Culture is most relevant where external pressure operates through values, legitimacy, and accepted understandings of appropriate organizational behavior (Tavallaei et al., 2022; Alankarage et al., 2023). For this reason, the present study limits the moderating role of Corporate Culture to the relationship between Normative Pressures and BIM adoption. This focus is conceptually appropriate

because normative pressure and culture are closely linked through shared values, legitimacy judgments, and professional expectations (DiMaggio & Powell, 1983; Alankarage et al., 2023).

This study present is anchored in five cumulative propositions. First, BIM has evolved into a broader organizational and information-management innovation rather than remaining a narrow technical tool (Succar, 2009; Borkowski, 2023). Second, BIM diffusion is globally uneven, with developing countries still facing substantial adoption difficulties (Adekunle et al., 2021). Third, the MENA region reflects structural and human barriers that make BIM adoption more complex than in mature environments (El Hajj et al., 2023). Fourth, Libya presents a particularly important case because BIM maturity remains weak and practical implementation is still limited (Elghdhan et al., 2023; Solla et al., 2025). Fifth, these conditions justify a study that explains BIM adoption through technological, organizational, and environmental factors while testing a focused moderating role for Corporate Culture only in the relationship between Normative Pressures and BIM adoption (Tavallaei et al., 2022; Alankarage et al., 2023).

Table 1: Core Background Premises Underpinning the Study

Background premise	Position in the literature	Relevance to the present study
BIM is broader than software	BIM is increasingly defined as an information-management and organizational approach rather than a mere Modeling tool	Justifies treating BIM adoption as an organizational outcome
BIM is a socio-technical innovation	BIM adoption involves process change, coordination change, and organizational learning, not technical acquisition alone	Justifies examining technological and organizational factors together
BIM diffusion is uneven	Adoption remains unequal across countries and industries, especially in developing contexts	Justifies focusing on Libya as a context-specific case
BIM adoption is institutionally shaped	External expectations, legitimacy, and professional norms influence adoption decisions	Justifies including environmental pressures in the model

Internal interpretation matters	Organizations do not respond to external signals in a culturally neutral way	Justifies the focused moderating role of Corporate Culture
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Source: Developed by the researcher based on Succar (2009), Borkowski (2023), Chowdhury et al. (2024), Adekunle et al. (2021), and Tavallaei et al. (2022).

Table 1 shows why BIM must be approached as an organizational innovation, why diffusion cannot be assumed to be uniform across contexts, and why both external pressures and internal interpretation are relevant to the study (Succar, 2009; Chowdhury et al., 2024; Tavallaei et al., 2022).

Table 2: Background Patterns of BIM Diffusion from the Global to the Libyan Context

Analytical level	Main pattern in the literature	Background implication for this study
Global BIM literature	BIM is increasingly recognized as an organizational and lifecycle-oriented digital innovation	The study must treat BIM as more than software adoption
Developing-country literature	BIM diffusion remains uneven and often immature	The study must avoid assuming that mature-country patterns automatically apply
MENA literature	Barriers include structural, human, financial, and institutional constraints	The study must consider environmental and organizational complexity
Libya-specific literature	BIM maturity is weak, practical experience is limited, and conventional methods remain dominant	The study requires a context-specific organizational adoption model

Source: Developed by the researcher based on Adekunle et al. (2021), El Hajj et al. (2023), Elghdhan et al. (2023), and Solla et al. (2025).

Table 2 situates Libya within a wider gradient of BIM diffusion, beginning from global conceptual development, moving through developing-country and MENA evidence, and ending in the Libyan construction sector (Adekunle et al., 2021; El Hajj et al., 2023; Elghdhan et al., 2023).

Table 3: Background Justification for the Final Study Variables

Background issue identified in the literature	Variable or relationship justified
BIM is evaluated as difficult, beneficial, and more or less fitting to existing workflows	Complexity, Relative Advantages, Compatibility
BIM adoption requires internal commitment and implementation capacity	Top Management Support, Organizational Readiness
BIM diffusion is associated with competition, dependency, and legitimacy pressures	Mimetic Pressures, Coercive Pressures, Normative Pressures
Organizational responses to professional expectations are filtered through internal values and assumptions	Corporate Culture as moderator
The strongest conceptual overlap exists between legitimacy-based pressure and internal cultural interpretation	Corporate Culture × Normative Pressures → BIM adoption

Source: Developed by the researcher based on Tavallaei et al. (2022), Chowdhury et al. (2024), Alankarage et al. (2023).

Table 3 shows that the variables are not chosen arbitrarily. Each of them emerges from a specific strand of the background literature, and the focused moderating relationship is justified by a specific conceptual convergence between normative pressure and cultural interpretation (Tavallaei et al., 2022; Alankarage et al., 2023; Chowdhury et al., 2024).

1.2. Research Problem

Building Information Modeling has become one of the most influential digital developments in the construction industry because it improves information integration, coordination, productivity, and collaboration across the project life cycle. However, its diffusion has remained highly uneven across countries and organizational environments. Adekunle et al. (2021) show that BIM adoption in developing countries is still at an early stage

and remains constrained by substantial implementation barriers, while Chowdhury et al. (2024) argue that BIM adoption research has often been too narrow because it has not sufficiently captured the organizational environment, social structure, power relations, and culture that shape adoption processes. This means that the central issue is no longer whether BIM is valuable in principle, but why its recognized value still fails to produce stable organizational adoption in many developing construction contexts (Adekunle et al., 2021; Chowdhury et al., 2024).

This general problem becomes more acute in the Libyan construction sector, where the need for coordinated and information-rich project delivery is strong, yet the organizational and institutional conditions required for BIM adoption remain weak. The IMF's 2024 assessment describes a setting marked by political uncertainty, fragmented institutions, and persistent capacity constraints, all of which make effective planning, budgeting, coordination, and implementation more difficult (International Monetary Fund, 2024). In such an environment, digital systems that improve information quality and coordination should be especially valuable. Yet Libya-specific BIM evidence indicates that the sector has not institutionalized BIM as a routine organizational practice. Solla et al. (2023) report that the Libyan construction industry still faces major BIM barriers, especially lack of awareness, cost, lack of government support, lack of standards, limited IT infrastructure, and resistance to change. These barriers show that the Libyan BIM problem is not simply a software-access issue. It is a broader sectoral and organizational problem involving weak preparedness, weak support structures, and limited implementation capacity (Solla et al., 2023; International Monetary Fund, 2024).

The practical seriousness of this issue is reinforced by more recent Libya-based applied evidence. Solla et al. (2025) state that conventional cost-estimation methods in Libya remain inefficient, manual, and vulnerable to human error, and their survey results show that spreadsheet-based estimation is still dominant in practice. The same study reports that most surveyed firms had no meaningful BIM experience, which indicates that BIM remains weakly embedded in daily professional operations rather than being an established organizational norm (Solla et al., 2025). Therefore, the practical problem addressed in this study is not merely the existence of barriers in the abstract. The practical problem is that the Libyan construction sector continues to rely heavily on fragmented and conventional work methods despite the availability of a digital approach that could improve estimation accuracy, coordination quality, and broader project performance (Solla et al., 2025).

Although the BIM literature has identified many adoption drivers and barriers, it still does not provide a sufficiently integrated explanation of organizational adoption in challenging contexts. Chowdhury et al. (2024) explicitly note a tendency toward tunnel vision in the BIM adoption literature, meaning that studies often isolate a single organizational aspect or a single adoption phase instead of explaining how BIM interacts with multiple organizational elements before and after adoption. This limitation is important because BIM adoption is not a narrow technical choice. It is an organizational transformation process affected simultaneously by innovation characteristics, internal capabilities, and environmental expectations. A broad adoption structure is therefore necessary, and the Technology-Organization-Environment framework provides that structure. Yet broad structure alone is not enough. Tavallaei et al. (2022) show that institutional pressures matter directly for BIM adoption and that normative pressure is the most prominent institutional pressure affecting BIM adoption across AEC organizations. Their findings suggest that the external environment should not be treated as a generic background condition. It operates through differentiated pressures, and some of those pressures are more influential than others (Chowdhury et al., 2024; Tavallaei et al., 2022).

A further unresolved issue concerns Corporate Culture. In BIM-specific scholarship, Alankarage et al. (2023) identify organizational and professional culture change as an underdeveloped area of BIM research and argue that culture is essential for understanding BIM-related transformation. In adjacent organizational research, Dai et al. (2018) show that organizational culture moderates the relationship between market pressures and proactive environmental strategy, while Behl et al. (2022) find that organizational culture plays a critical moderating role in technology adoption in another complex operational setting. Taken together, these studies support the argument that culture should not be treated merely as descriptive background. It can shape how external pressures are interpreted and converted into organizational action. However, the literature does not justify an unrestricted claim that culture moderates every path in a BIM adoption model. A more rigorous position is that Corporate Culture is most plausibly connected to normative pressure because normative pressure operates through values, legitimacy, professional expectations, and conceptions of appropriate practice, all of which are closely aligned with the interpretive role of culture inside organizations (Alankarage et al., 2023; Dai et al., 2018; Behl et al., 2022).

Accordingly, the study is that BIM remains insufficiently adopted at the organizational level in the Libyan construction sector despite its recognized strategic and operational value, while the current literature still lacks a sufficiently integrated and context-sensitive explanation

of that weak adoption. The Libyan evidence demonstrates persistent practical barriers related to awareness, cost, governmental support, standards, infrastructure, and resistance to change. The broader BIM literature suggests that fragmented factor-based explanations are inadequate when organizational environment, institutional pressures, and culture are not brought together. The remaining unresolved issue is whether Corporate Culture conditions the relationship between Normative Pressures on BIM adoption in Libya. For this reason, the present study addresses a combined practical, theoretical, contextual, and model-specific problem by examining the effects of technological, organizational, and environmental factors on BIM adoption in the Libyan construction sector and by testing whether Corporate Culture moderates the relationship between Normative Pressures and BIM adoption (Solla et al., 2023; Tavallaei et al., 2022; Alankarage et al., 2023).

Table 4: Empirical Indicators of Weak BIM Maturity in the Libyan Construction Sector

Indicator	Evidence	Academic meaning
Highest BIM application stage	Design stage, mean = 3.96	BIM visibility is stronger in design than in later life-cycle stages
Construction-stage BIM application	Mean = 3.50	BIM is less embedded in execution-stage practice
Renovation and demolition application	Mean = 2.94	Full life-cycle adoption remains weak
Revit usage	53%	Tool usage is concentrated rather than broadly diversified
Firms with no previous BIM experience	75%	Most firms still lack accumulated BIM capability
Firms that never use BIM in projects	72.5%	Project-level adoption remains very low
Use of spreadsheets/computer programs for estimating	70%	Traditional digital tools dominate over BIM-based estimating
Use of traditional manual methods	57.5%	Conventional workflows remain significant

Source: Developed by the researcher from Solla et al. (2023, Table II) and Solla et al. (2025, Table 3).

The stage-based indicators show that BIM use in Libya is partial rather than life-cycle-wide, while the project-level and experience-based indicators show that BIM has not yet matured into routine organizational practice (Solla et al., 2023; Solla et al., 2025), as show in Table 4.

Table 5. Ranked Practical Barriers to BIM Adoption in Libya

Barrier	Mean value	Rank	Link to the study variables
Lack of awareness	3.64	1	Weakens technological understanding and organizational readiness
Cost	3.49	2	Constrains readiness, training, and implementation capacity
Lack of government support	3.45	3	Reflects environmental and institutional weakness
Lack of standards	2.91	4	Reflects environmental weakness and weak normative infrastructure
Limited IT infrastructure	2.86	5	Reflects technological and organizational capacity limitations
Resistance to change	2.80	6	Reflects internal organizational and cultural constraints

Source: Adapted from Solla et al. (2023, Table III, “BIM Barriers in Libyan Construction”).

Table 5 is used because weak BIM maturity alone does not explain why adoption remains weak. A convincing problem section must identify the specific sources of that weakness. This Table 5 transforms the problem from a general statement into an ordered barrier structure. It also links directly to the variables of the study. Lack of awareness and limited IT infrastructure justify examining technological factors. Cost and training-related implications justify examining organizational readiness. Lack of government support and lack of standards justify examining environmental pressures. Resistance to change makes it reasonable to

consider the internal interpretive role of Corporate Culture (Solla et al., 2023; Elghdhan et al., 2023).

Table 6. From Practical Evidence to Theoretical Gap and Model Response

Evidence stream	What the literature establishes	What remains unresolved	Why this table is needed
Developing-country BIM diffusion	BIM diffusion in developing countries remains uneven and immature	Libya still lacks a sufficiently integrated country-specific explanation	It justifies the contextual need for the study
Libya-specific empirical evidence	BIM maturity is weak, project-level use is low, and barriers are ranked and visible	Practical evidence exists, but it remains fragmented across awareness, barriers, and applications	It shows that the problem is real but not yet theoretically consolidated
Institutional BIM evidence	Normative pressure is especially influential in BIM adoption	The Libya-specific role of normative pressure still needs direct testing	It justifies the environmental and institutional focus
BIM culture evidence	Culture is essential but underdeveloped in BIM research	The conditioning role of culture in Libyan BIM adoption remains insufficiently specified	It justifies including Corporate Culture
Final model logic	Technology, organization, and environment matter, but culture should not be generalized across all paths	The most defensible moderation path is Corporate Culture × Normative Pressures → BIM adoption	It aligns the gap directly with the final conceptual model

Source: Developed by the researcher from Adekunle et al. (2021), Tavallaei et al. (2022), Alankarage et al. (2023), Chowdhury et al. (2024), Elghdhan et al. (2023), Solla et al. (2023), and Solla et al. (2025).

This Table 6 connects the empirical evidence of weak adoption in Libya to the unresolved theoretical question in the literature and then shows how the current study answers that question through a focused, non-overextended model (Adekunle et al., 2021; Tavallaei et al., 2022; Chowdhury et al., 2024).

1.3. Research Questions

In light of the research problem presented in the previous section, the present study is guided by a set of research questions that translate the conceptual model into a clear empirical inquiry. These questions are intended to examine the relationships between technological, organizational, and environmental factors and BIM adoption in the Libyan construction sector, and to determine whether Corporate Culture moderates the relationship between Normative Pressures and BIM adoption. This wording is methodologically more appropriate because the study adopts a quantitative cross-sectional survey design and uses PLS-SEM to examine statistically significant relationships among the study constructs rather than to establish strict temporal causality in an experimental sense, as also reflected in the revised wording of the research objectives in Section 1.4.

RQ1. What is the relationship between technological factors and BIM adoption in the Libyan construction sector?

RQ1a. What is the relationship between Complexity and BIM adoption in the Libyan construction sector?

RQ1b. What is the relationship between Relative Advantages and BIM adoption in the Libyan construction sector?

RQ1c. What is the relationship between Compatibility and BIM adoption in the Libyan construction sector?

RQ2. What is the relationship between organizational factors and BIM adoption in the Libyan construction sector?

RQ2a. What is the relationship between Top Management Support and BIM adoption in the Libyan construction sector?

RQ2b. What is the relationship between Organizational Readiness and BIM adoption in the Libyan construction sector?

RQ3. What is the relationship between environmental factors and BIM adoption in the Libyan construction sector?

RQ3a. What is the relationship between Mimetic Pressures and BIM adoption in the Libyan construction sector?

RQ3b. What is the relationship between Coercive Pressures and BIM adoption in the Libyan construction sector?

RQ3c. What is the relationship between Normative Pressures and BIM adoption in the Libyan construction sector?

RQ4. Does Corporate Culture moderate the relationship between Normative Pressures and BIM adoption in the Libyan construction sector?

1.4. Research Objectives

Based on the research problem and research questions, the present study seeks to achieve a set of objectives that are fully aligned with the conceptual model of the study. These objectives are intended to examine the relationships between technological, organizational, and environmental factors and Building Information Modeling adoption in the Libyan construction sector, and to assess the moderating role of Corporate Culture in the relationship between Normative Pressures and BIM adoption. In this sense, the study is designed to explain the extent to which the specified constructs are statistically associated with organizational BIM adoption within the Libyan construction context, rather than to claim strict temporal causality in an experimental sense, which is consistent with the cross-sectional survey design and the PLS-SEM analytical approach adopted in the study. The general objective of the study is to examine the relationships between technological, organizational, and environmental factors and BIM adoption in the Libyan construction sector, with Corporate Culture as a moderating variable. This objective is consistent with the theoretical structure of the study, which integrates the TOE framework, Institutional Theory, and a focused cultural moderation perspective in order to explain organizational BIM adoption in an underexplored construction context.

RO1. To examine the relationship between Complexity and BIM adoption in the Libyan construction sector.

RO2. To examine the relationship between Relative Advantages and BIM adoption in the Libyan construction sector.

RO3. To examine the relationship between Compatibility and BIM adoption in the Libyan construction sector.

RO4. To examine the relationship between Top Management Support and BIM adoption in the Libyan construction sector.

RO5. To examine the relationship between Organizational Readiness and BIM adoption in the Libyan construction sector.

RO6. To examine the relationship between Mimetic Pressures and BIM adoption in the Libyan construction sector.

RO7. To examine the relationship between Coercive Pressures and BIM adoption in the Libyan construction sector.

RO8. To examine the relationship between Normative Pressures and BIM adoption in the Libyan construction sector.

RO9. To examine whether Corporate Culture moderates the relationship between Normative Pressures and BIM adoption in the Libyan construction sector.

1.5. Significance of the Study

The significance of the present study lies in its ability to address an insufficiently resolved problem in the construction-management and technology-adoption literature, namely the weak organizational adoption of Building Information Modeling in a context characterized by institutional constraint, uneven digital readiness, and limited implementation maturity. The study is significant because it examines BIM adoption through an integrated analytical perspective that combines technological, organizational, and environmental factors with a focused moderating role for Corporate Culture. In doing so, it contributes to theory, practice, and contextual knowledge at the same time (Adekunle et al., 2021; Elghdhan et al., 2023; Chowdhury et al., 2024; Solla et al., 2023; Solla et al., 2025).

1.5.1. Significance to Theory

The theoretical significance of the present study lies first in its effort to explain Building Information Modeling adoption as an organizational and institutional phenomenon rather than as a narrow technical or software decision. This distinction is important because BIM is more

appropriately understood as a wider information-centered, process-oriented, and lifecycle-based organizational innovation (Succar, 2009; Borkowski, 2023; Chowdhury et al., 2024). Once BIM is positioned in this way, adoption cannot be explained adequately through perceived utility or technological availability alone. It must be examined through interrelated technological, organizational, environmental, and interpretive conditions (Tornatzky & Fleischer, 1990; Tavallaei et al., 2022).

A second theoretical significance of the study lies in the way it consolidates the TOE framework as the primary organizational structure for explaining BIM adoption. The study is theoretically significant because it does not employ TOE in a generic manner. Instead, it specifies the technological domain through Complexity, Relative Advantages, and Compatibility, the organizational domain through Top Management Support and Organizational Readiness, and the environmental domain through Mimetic Pressures, Coercive Pressures, and Normative Pressures (Tornatzky & Fleischer, 1990; Elghdhan et al., 2023; Tavallaei et al., 2022). This specification strengthens theoretical clarity because each domain of TOE is translated into distinct constructs with a direct conceptual link to BIM adoption.

The study is also theoretically significant because it gives greater depth to the environmental domain by refining it through Institutional Theory. External influence does not operate as a single undifferentiated background condition. It operates through distinct forms of pressure, namely mimetic, coercive, and normative pressures (DiMaggio & Powell, 1983). Recent BIM research indicates that normative pressure is especially important because organizations respond not only to technical efficiency but also to what is considered legitimate, modern, and professionally appropriate practice (Tavallaei et al., 2022). This allows the present study to advance BIM adoption theory beyond a generic external-environment category.

The strongest theoretical contribution of the study lies in its disciplined treatment of Corporate Culture. The study does not generalize the moderating relationship between culture across all technological, organizational, and environmental relationships. Instead, it restricts the moderating role of Corporate Culture to the relationship between Normative Pressures and BIM adoption, because this is the pathway where culture is conceptually most relevant (Alankarage et al., 2023; Dai et al., 2018; Behl et al., 2022). This restriction itself is a theoretical contribution because it introduces conceptual boundary and prevents theoretical overextension.

The study is further significant because it extends BIM adoption theory into an underrepresented empirical context. Much of the stronger BIM literature has emerged from

more mature digital environments, while developing-country and transitional settings remain less examined (Adekunle et al., 2021; Chowdhury et al., 2024). By focusing on Libya, the study tests whether established adoption mechanisms remain valid under conditions of limited BIM maturity, uneven institutional support, and constrained implementation capacity (Elghdhan et al., 2023; Solla et al., 2025). In this sense, the study contributes to the comparative development of BIM adoption theory as a more context-sensitive field of inquiry.

1.5.2. Significance to Practice

The practical significance of the present study lies in its ability to generate evidence that is useful for organizations and institutions seeking to improve BIM adoption in the Libyan construction sector. Existing Libya-specific evidence indicates weak BIM maturity, low project-level use, limited prior experience, and persistent dependence on conventional tools and workflows (Elghdhan et al., 2023; Solla et al., 2023; Solla et al., 2025). Under such conditions, practical improvement requires more than general advocacy for digital transformation. It requires a clearer understanding of which conditions matter most, how they interact, and where intervention is most needed.

At the level of construction firms, the study can help managers move from vague assumptions about BIM to a more evidence-based understanding of adoption. By separating the model into technological, organizational, and environmental dimensions, the study can help firms diagnose whether the main obstacle lies in perceived complexity, weak perceived advantage, low compatibility, limited readiness, insufficient managerial support, or adverse external conditions (Elghdhan et al., 2023; Tavallaei et al., 2022). This diagnostic value is one of the major practical strengths of the study.

The practical significance is equally strong in relation to organizational management. Top Management Support concerns strategic commitment and internal legitimacy, while Organizational Readiness concerns capability, skills, processes, and implementation preparedness (Tavallaei et al., 2022). This distinction is practically valuable because firms can fail in two different ways. They may fail because leadership does not treat BIM as a strategic priority, or they may fail because the organization is not prepared to operationalize BIM even when leadership is supportive.

The study also has direct practical significance for project coordination and operational performance. Construction work is coordination-intensive, project-based, and dependent on communication and information exchange across multiple actors. Any evidence that clarifies

the predictors of BIM adoption can help firms improve how they manage interdependent project actors and implementation priorities in real construction practice (Succar, 2009; Tavallaei et al., 2022).

At the sectoral level, the practical significance of the study lies in its implications for the external environment of BIM diffusion. Government agencies, procurement bodies, professional associations, and higher-education institutions can use the findings to strengthen standards, awareness, training, and professional expectations around BIM adoption (El Hajj et al., 2023; Tavallaei et al., 2022). If normative pressure proves especially influential, then profession-led normalization and legitimacy-building become particularly important.

Another major practical significance lies in the role of Corporate Culture. Even if the external professional environment becomes more favorable to BIM, organizations may still respond differently depending on whether their internal culture supports learning, collaboration, innovation, and openness to change (Alankarage et al., 2023). The study is therefore practically significant because it encourages managers to treat culture as an implementation condition rather than as an abstract background characteristic.

Finally, the practical significance of the present study lies in its potential to support evidence-based decision-making across several levels of the construction system. For firm managers, it offers a guide to internal adoption priorities. For consultants and project leaders, it offers a basis for more strategic coordination and implementation planning. For policymakers and institutions, it offers evidence for designing standards, training, and support mechanisms. For educators and professional bodies, it offers guidance for capability development and professional normalization. In this way, the study does not merely explain a problem. It generates knowledge that can be used to act on that problem in a structured way.

1.6. Scope of the Study

The scope of the present study is defined in a conceptually precise and methodologically disciplined manner in order to preserve coherence between the research problem, the conceptual model, and the empirical analysis (Tornatzky & Fleischer, 1990; Tavallaei et al., 2022). The study is confined to Building Information Modeling adoption as an organizational innovation outcome, rather than to the broader technical functionalities of BIM or to the consequences that may arise after adoption has already occurred (Succar, 2009; Chowdhury et al., 2024). Accordingly, the study does not investigate implementation depth, post-adoption usage intensity, project performance gains, or lifecycle efficiency outcomes after BIM has been

introduced into practice. Its focus is restricted to the antecedent conditions that explain organizational adoption itself (Adekunle et al., 2021; Tavallaei et al., 2022).

The conceptual scope of the study is further delimited by the specific variables contained in the finalized research model. BIM adoption is treated as the dependent variable, while Complexity, Relative Advantages, Compatibility, Top Management Support, Organizational Readiness, Mimetic Pressures, Coercive Pressures, and Normative Pressures are treated as the direct explanatory variables of the model (Elghdhan et al., 2023; Tavallaei et al., 2022). Corporate Culture is incorporated as a moderating variable, but its role is intentionally restricted to the relationship between Normative Pressures and BIM adoption (Alankarage et al., 2023; Tavallaei et al., 2022). This restriction is theoretical because a generalized claim that Corporate Culture moderates all model relationships would weaken conceptual precision and extend the moderator beyond its most defensible explanatory boundary (Alankarage et al., 2023; DiMaggio & Powell, 1983).

Contextually, the study is confined to the Libyan construction sector. This boundary is necessary because BIM adoption remains uneven across countries and institutional environments, and the adoption conditions observed in mature construction markets cannot be assumed to operate in the same way in more constrained settings (Adekunle et al., 2021; Chowdhury et al., 2024). Libya represents a particularly relevant empirical context because the available evidence indicates that BIM maturity remains limited, organizational experience is weak, and practical implementation is still constrained by barriers related to awareness, cost, standards, infrastructure, and governmental support (Solla et al., 2023; Solla et al., 2025).

Sectorally, the study is restricted to the construction industry and to respondents whose professional roles are directly connected to construction practice in Libya. This delimitation is justified because BIM is not a generic digital tool detached from sectoral structure, but a construction-specific organizational innovation associated with coordination demands, project-based workflows, and interdependent professional interaction (Succar, 2009; Tavallaei et al., 2022). It does not extend to non-construction sectors, unrelated digital transformation contexts, or purely academic perceptions detached from real construction practice (Adekunle et al., 2021).

At the analytical level, the study addresses BIM adoption at the organizational level rather than at the level of individual user acceptance alone. This analytical delimitation is important because the selected variables, including Top Management Support, Organizational Readiness,

Mimetic Pressures, Coercive Pressures, Normative Pressures, and Corporate Culture, are conceptually meaningful primarily at the organizational level, where adoption is associated with strategic commitment, institutional exposure, and shared internal conditions rather than by isolated personal preference (Tavallaei et al., 2022; Elghdhan et al., 2023). Although the empirical data are collected from individual respondents, those responses are used as indicators of organizational conditions relevant to BIM adoption rather than as expressions of purely personal technology-use attitudes.

Methodologically, the study is restricted to a quantitative and cross-sectional design intended to test the relationships specified in the conceptual model. It does not seek to produce a longitudinal history of BIM diffusion, an ethnographic interpretation of organizational culture, or a comparative cross-national analysis of digital transformation in construction (Adekunle et al., 2021; Chowdhury et al., 2024; Tornatzky & Fleischer, 1990; Tavallaei et al., 2022).

1.7. Definition of Key Terms

The study adopts operational and study-specific definitions for its key terms in order to preserve conceptual precision and ensure consistency between the research problem, the conceptual model, and the empirical analysis. The definitions presented below are therefore not intended as broad dictionary meanings. Rather, they reflect the way each construct is understood within the analytical boundaries of the study.

1.7.1. Building Information Modeling Adoption

Building Information Modeling adoption refers to the organizational decision and progressive movement toward accepting BIM as an innovation within the firm, rather than merely recognizing its existence or using isolated digital tools (Succar, 2009; Ahmed & Kassem, 2018). In the present study, BIM adoption is treated as an organizational-level outcome that reflects the extent to which BIM has moved from a conceptual or informal idea into a more formalized and institutionally supported organizational practice (Succar, 2009; Ahmed & Kassem, 2018). This means that BIM adoption is understood here in terms of organizational commitment, structured uptake, and continued integration into firm-level practice, rather than in terms of simple awareness or short-term experimentation alone (Ahuja et al., 2016; Ahmed & Kassem, 2018). Accordingly, the construct captures whether the organization has formally decided to adopt BIM, whether BIM is currently used in projects, whether procedures or guidelines for BIM use have been established, whether BIM use is supported at the organizational level, whether the organization intends to expand BIM use in future projects, whether BIM has become part of the regular way of working, and whether resources are

allocated to sustain continued BIM use (Succar, 2009; Ahmed & Kassem, 2018; Ahuja et al., 2016). This operationalization is consistent with the literature that treats BIM adoption as an organizational innovation process rather than a purely individual or software-based event, and it is especially appropriate in construction-sector research where institutionalization, routinization, and resource commitment are central to adoption itself (Succar, 2009; Ahmed & Kassem, 2018; Ahuja et al., 2016).

1.7.2. Complexity

Complexity refers to the extent to which Building Information Modeling is perceived as demanding and challenging in terms of understanding, integration, coordination, and operational handling within the organization (Ullah et al., 2022; Shirowzhan et al., 2020). In the present study, TCO refers to the perceived manageability of BIM-related complexity rather than to complexity as a purely inhibiting barrier. More specifically, the construct reflects the extent to which BIM-related demands can be understood, handled, coordinated, and integrated into organizational practice without excessive burden or disruption (Ahmed & Kassem, 2018; Succar, 2009). Accordingly, higher values on TCO indicate that BIM-related complexity is perceived as more manageable within the organization, which is more consistent with positive organizational movement toward BIM adoption in the present study (Succar, 2009; Ahmed & Kassem, 2018; Ullah et al., 2022).

1.7.3. Relative Advantages

Relative Advantages refer to the degree to which BIM is perceived as offering superior benefits when compared with traditional approaches to design, coordination, communication, and information management. In the present study, this construct captures whether BIM is viewed as a more beneficial and worthwhile innovation than conventional methods, which should increase the likelihood of adoption (Ahmed & Kassem, 2018; Elghdhan et al., 2023).

1.7.4. Compatibility

Compatibility refers to the extent to which BIM is perceived as fitting the organization's existing workflows, routines, technical systems, and operational needs. In the present study, the construct is used to capture whether BIM can be integrated into the existing working environment without creating excessive disruption to established organizational practices (Ahmed & Kassem, 2018; Elghdhan et al., 2023).

1.7.5. Top Management Support

Top Management Support refers to the degree to which senior organizational leaders endorse, legitimize, and support the adoption of BIM through strategic commitment, resource allocation, and visible backing for digital change. Stronger top management support indicates a more favorable organizational condition for BIM adoption (Tavallaei et al., 2022; Elghdhan et al., 2023).

1.7.6. Organizational Readiness

Organizational Readiness refers to the extent to which an organization possesses the internal capability and preparedness required to adopt BIM successfully. In the present study, readiness includes the availability of relevant knowledge, skills, structures, processes, and implementation conditions that allow BIM to move from strategic intention to operational reality (Tavallaei et al., 2022; Elghdhan et al., 2023).

1.7.7. Mimetic Pressures

Mimetic Pressures refer to the external pressure felt by organizations to imitate other organizations that are perceived as successful, legitimate, or strategically advanced, particularly under conditions of uncertainty. In the present study, mimetic pressures capture the extent to which firms may be influenced to adopt BIM because competitors, consultants, partners, or leading organizations in the field are already using it or are seen to benefit from it (DiMaggio & Powell, 1983; Tavallaei et al., 2022).

1.7.8. Coercive Pressures

Coercive Pressures refer to external pressures arising from formal authority, dependency relationships, contractual requirements, or expectations imposed by powerful actors such as governments, clients, regulators, or dominant project partners. In the present study, coercive pressures capture the extent to which organizations may move toward BIM adoption because adoption is required, expected, or strongly encouraged by actors whose demands cannot easily be ignored (DiMaggio & Powell, 1983; Tavallaei et al., 2022).

1.7.9. Normative Pressures

Normative Pressures refer to the influence of professional norms, accepted standards, educational systems, expert discourse, and shared expectations regarding what constitutes appropriate and legitimate practice within an organizational field. In the present study, normative pressures capture the extent to which BIM is perceived as a professionally endorsed,

credible, and increasingly expected way of organizing design, coordination, and information management in the construction sector (DiMaggio & Powell, 1983; Tavallaei et al., 2022).

1.7.10. Corporate Culture

Corporate Culture refers to the shared values, norms, beliefs, and internal organizational orientations that shape how members of the organization interpret change, collaboration, learning, and innovation-related action within the firm (Alankarage et al., 2023; Dai et al., 2018; Behl et al., 2022). In the present study, Corporate Culture is treated as a focused moderating variable that conditions how organizations respond internally to professionally endorsed external expectations concerning BIM adoption. More specifically, the construct reflects whether the organization encourages openness to new ways of working, supports learning and continuous improvement, promotes collaboration across functions, welcomes change initiatives, and sustains senior-management values supportive of innovation and organizational development. Accordingly, Corporate Culture in the present study captures a general internal cultural condition rather than a BIM-specific supportive attitude alone, which makes its moderating role conceptually more consistent with the theoretical logic of the study (Alankarage et al., 2023; Dai et al., 2018; Behl et al., 2022).

1.8. Thesis Organization

This study is organized into five interrelated chapters in order to ensure a coherent progression from problem identification to theoretical grounding, methodological design, empirical analysis, and final interpretation. The structure has been designed to maintain full consistency between the research problem, the conceptual framework, the analytical procedures, and the final contribution of the study. Each chapter performs a distinct academic function, while at the same time contributing to the cumulative logic of the study as a whole.

Chapter One introduces the study and establishes its overall intellectual direction. It presents the research background, research problem, research questions, research objectives, significance of the study, scope of the study, and key terms. The chapter therefore provides the conceptual and contextual foundation of the study and clarifies the academic rationale for examining BIM adoption in the Libyan construction sector.

Chapter Two presents the literature review and develops the theoretical and conceptual foundation of the study. It reviews the concept and evolution of Building Information Modeling, examines the relevant technological, organizational, and environmental factors, and explains the theoretical basis of the study through the TOE framework, Institutional Theory,

and the literature on Corporate Culture. The chapter also synthesizes the empirical literature, identifies the research gap, and develops the conceptual framework and hypotheses of the study.

Chapter Three explains the methodology adopted in the study. It describes the research design, target population, sampling procedure, data collection method, measurement of variables, and analytical techniques used to test the proposed model. The purpose of this chapter is to demonstrate that the empirical procedures of the study are appropriate to its objectives, research questions, and conceptual structure.

Chapter Four presents the empirical results of the study. It reports the descriptive profile of the respondents, the statistical characteristics of the variables, and the inferential results used to test the proposed relationships. This chapter therefore translates the conceptual and methodological design of the study into empirical evidence and shows whether the proposed relationships are supported by the data.

Chapter Five concludes the study by discussing the findings in relation to the research problem, theoretical framework, and existing literature. It presents the theoretical contributions, practical implications, limitations of the study, and recommendations for future research. In this way, the final chapter integrates the results of the study and clarifies its contribution to knowledge and practice in the field of BIM adoption in the Libyan construction sector.

2. CHAPTER TWO: LITERARY REVIEW

2.1. Introduction

This chapter reviews the theoretical, conceptual, and empirical literature relevant to Building Information Modeling adoption in the construction industry and establishes the scholarly foundation for the model developed in this study. The chapter proceeds from the view that BIM adoption is not a narrow software decision, but an organizational innovation process associated with technological conditions, organizational capabilities, environmental pressures, and internal cultural interpretation. The chapter begins by clarifying the meaning of BIM, tracing its evolution in the construction industry, and distinguishing BIM adoption from related concepts such as BIM use and BIM implementation, because conceptual precision is essential before organizational adoption can be examined rigorously. It then establishes the theoretical foundation of the study through the Technology, Organization, and Environment framework, Institutional Theory, and the organizational culture literature, before reviewing the technological, organizational, and environmental predictors of BIM adoption and discussing Corporate Culture as a moderating variable.

2.2. Building Information Modeling, Concept, Evolution, and Organizational Adoption

Building Information Modeling occupies a foundational position in this study because the dependent variable is BIM adoption, and that variable cannot be treated rigorously without first clarifying what BIM is, how its meaning has evolved, and how adoption should be distinguished from related concepts such as use and implementation. The literature shows that BIM is no longer understood adequately as a three-dimensional digital model alone. It is

increasingly treated as a broader information-centered, process-oriented, and lifecycle-based approach to managing built assets and construction knowledge (Succar, 2009; Borkowski, 2023; ISO, 2024).

2.2.1. Definitions and Conceptual Foundations of BIM

The literature shows that there is still no single universally accepted definition of BIM, even though the concept has become central to the architecture, engineering, construction, and operations domain (Borkowski, 2023; Succar, 2009). A narrow definition usually treats BIM as a digital, object-based representation of a facility. A broader conceptualization treats BIM as an information management methodology spanning the lifecycle of a built asset, linking data creation, coordination, exchange, and use from design through construction and operation (Succar, 2009; ISO, 2024).

Conceptually, BIM should not be reduced to a software package or a modeling tool. It is more accurately understood as an integrated information environment in which digital representations, data structures, workflows, and collaboration mechanisms are connected to support project and asset decision making (Succar, 2009; Chowdhury et al., 2024). This broader understanding is particularly relevant for the present study because the research examines organizational BIM adoption, which requires a conceptual definition broad enough to encompass technology, process, coordination, and information governance together (Chowdhury et al., 2024; Wang et al., 2025), as shown in Table 7 and Figure 1.

Table 7: Major conceptual perspectives on BIM

Perspective	Main understanding of BIM	Core emphasis	Representative sources
BIM as a digital product	A digital, object-based model of a building or asset	3D representation, parametric objects, data-rich model	Borkowski (2023)
BIM as a process	A structured process for creating, coordinating, exchanging, and using project information	Collaboration, workflow integration, information exchange	Succar (2009); Chowdhury et al. (2024)
BIM as a system or methodology	A broader sociotechnical methodology combining policies, processes, technologies, and information governance across the asset lifecycle	Lifecycle information management, interoperability, coordinated decision support	Succar (2009); ISO (2024)

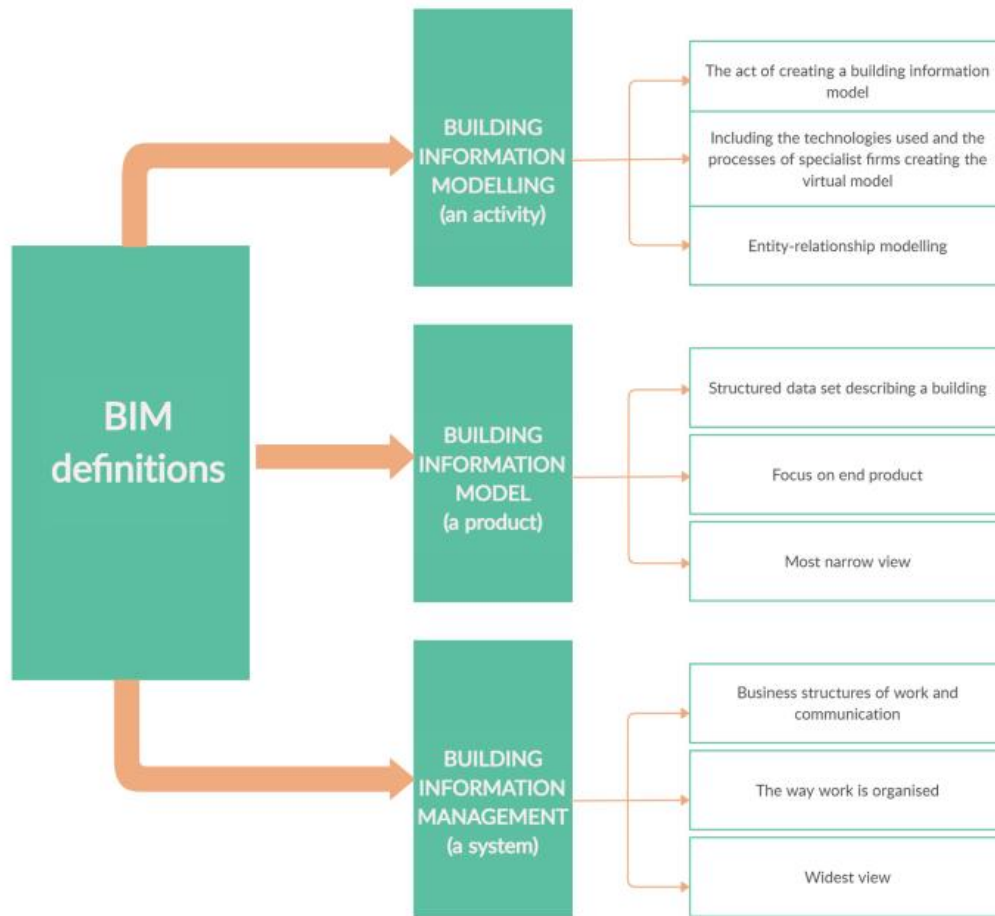


Figure 1: Different ways of looking at BIM.

Source: Adapted from Borkowski (2023, Figure 3).

2.2.2. Evolution of BIM in the Construction Industry

The literature shows that BIM did not emerge suddenly as a mature concept. It developed gradually from earlier streams of computer-aided design, product and process modeling, and digital representation research in construction and manufacturing-related fields (Borkowski, 2023). The concept became more recognizable in the late 1990s and early 2000s as the term BIM gained visibility and the industry moved beyond isolated digital drafting toward richer model-based representation and coordination (Borkowski, 2023; Succar, 2009).

A further stage in BIM’s evolution occurred when standards-based information management became more prominent. The ISO 19650 series marks an important institutional step in this development because it frames BIM as a structured approach to organizing and digitizing information about buildings and infrastructure across delivery and asset management phases (ISO, 2024). The literature therefore supports a clear interpretation of BIM evolution from a primarily model-centered digital representation concept toward a broader process and

information-management paradigm embedded in project delivery and asset lifecycle thinking (Succar, 2009; Borkowski, 2023; ISO, 2024), as shown in Figure 2.

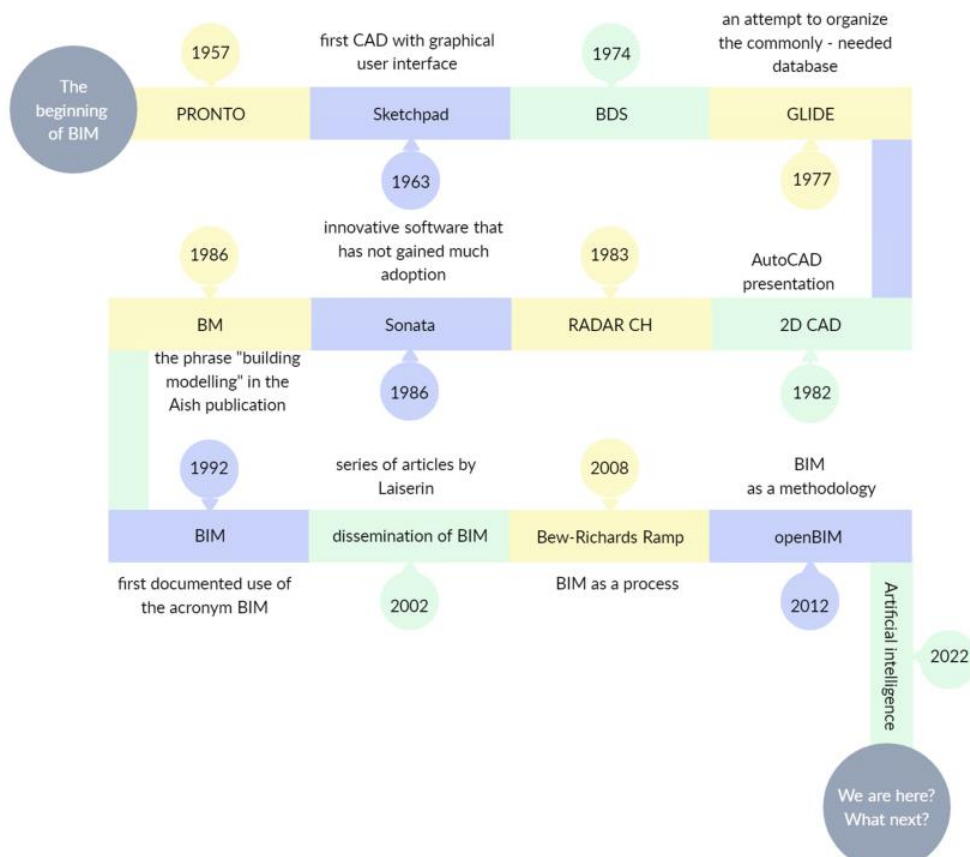


Figure 2: Timeline with major events and development of various concepts.

Source: Adapted from Borkowski (2023, Figure 2).

2.2.3. BIM as a Technological and Organizational Innovation

The literature increasingly treats BIM as both a technological innovation and an organizational innovation. It is technological because it involves digital tools, parametric objects, information structures, and interoperable data environments. It is organizational because its successful adoption requires changes in coordination, routines, roles, responsibilities, and collaborative practices across firms and projects (Succar, 2009; Chowdhury et al., 2024).

Recent BIM scholarship supports this broader interpretation. Chowdhury et al. (2024) argue that BIM adoption has moved from narrow, technology-centered explanations to a more holistic understanding. Murguia et al. (2021) likewise conceptualize BIM as a systemic innovation, meaning that its adoption requires multiple interdependent actors at user, firm, and project levels to change their practices if BIM’s benefits are to be realized. Arayici et al. (2011)

similarly argue that moving from CAD to BIM represents a fundamental change for architectural practices and must be approached systematically at the organizational level, as shown in Figure 3.

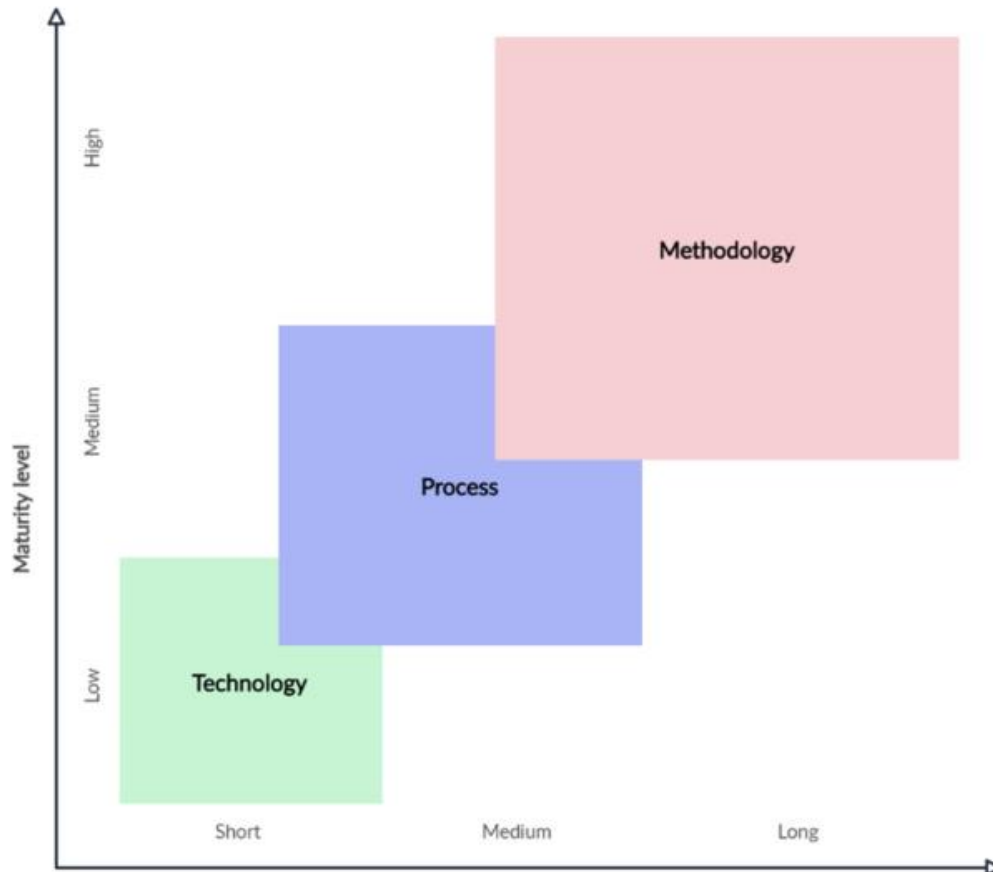


Figure 3. Evolution of the understanding of BIM.

Source: Adapted from Borkowski (2023, Figure 4).

2.2.4. BIM Adoption versus BIM Use and Implementation

The BIM literature frequently treats adoption, use, and implementation as closely related concepts, but it does not always distinguish them clearly. This lack of clarity matters because the present study examines BIM adoption specifically, and that construct should not be merged casually with later-stage concepts (Ahmed & Kassem, 2018; Saka et al., 2020).

At its simplest, BIM adoption refers to the organizational decision to accept or reject BIM as an innovation (Saka et al., 2020). BIM implementation, by contrast, refers to what happens after the adoption decision and involves the actual embedding of BIM within the organization (Arayici et al., 2011; Saka et al., 2020). BIM use refers to the actual application and intensity of BIM functions, tools, or workflows in practice, and usage levels may vary

substantially even after implementation begins (Wang, Yu, & Wu, 2025), as shown in Figure 4.

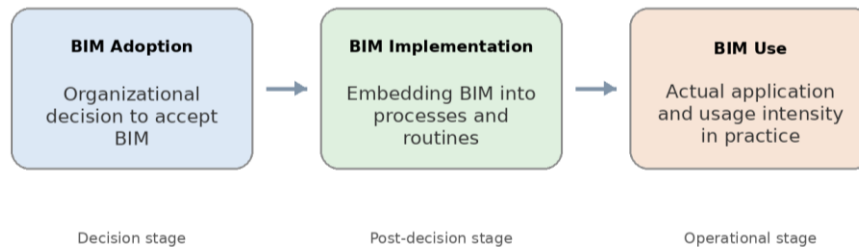


Figure 4. BIM adoption, implementation, and use continuum.

Source: Own elaboration based on Ahmed and Kassem (2018), Saka et al. (2020), and Wang, Yu, and Wu (2025).

Table 8: Distinction between BIM adoption, BIM implementation, and BIM use

Concept	Core meaning	Main stage	Main analytical focus	Representative sources
BIM adoption	The organizational decision to accept or reject BIM as an innovation	Pre-implementation and decision stage	Awareness, interest, decision, drivers, barriers	Ahmed and Kassem (2018); Saka et al. (2020)
BIM implementation	The organizational process of introducing, embedding, and operationalizing BIM after the decision to adopt	Post-decision stage	Rollout, integration, capability development, organizational change	Arayici et al. (2011); Saka et al. (2020)
BIM use	The actual application and intensity of BIM functions in projects or organizations	Operational stage	Usage levels, BIM functions, realized practice and performance	Wang, Yu, and Wu (2025)

2.2.5. General Benefits and Barriers of BIM Adoption

The literature consistently reports that BIM offers substantial potential benefits, although those benefits are not always realized fully in practice. At a general level, BIM is associated with stronger collaboration, better information coordination, improved visualization, more informed decision making, and more integrated lifecycle information management (ISO, 2024; Chowdhury et al., 2024). Quantitative and case-based work also suggests that BIM can generate time and cost savings during design and construction, while

operational benefits can emerge in areas such as maintenance planning and energy efficiency (Gharaibeh et al., 2024).

At the same time, the literature also shows that BIM adoption and implementation face recurring barriers, including interoperability problems, fragmented value chains, weak economic incentives for smaller firms, insufficient expertise, inadequate training, resistance to change, and weak guidance or institutional support (Abbasnejad et al., 2021; Burgess et al., 2026; Ndwandwe et al., 2024). The literature therefore presents BIM as a high-potential but condition-dependent innovation, as shown in Table 9.

Table 9. General benefits and barriers of BIM adoption

Dimension	Common benefits	Common barriers	Representative sources
Information and coordination	Better information integration, stronger collaboration, improved coordination across disciplines	Interoperability issues, fragmented workflows, weak data exchange practices	ISO (2024); Burgess et al. (2026)
Project delivery	Better visualization, improved decision making, potential time and cost savings, reduced rework	High implementation cost, split incentives, weak economic justification for smaller firms	Gharaibeh et al. (2024); Burgess et al. (2026)
Organizational capability	Improved planning support, stronger lifecycle information basis, better knowledge sharing potential	Lack of expertise, inadequate training, resistance to change, weak readiness	Abbasnejad et al. (2021); Ndwandwe et al. (2024)
Strategic and long-term value	Support for sustainability, maintenance planning, and wider digital transformation	Lack of guidance, limited institutional support, uneven market maturity	ISO (2024); Ndwandwe et al. (2024)

2.3. Theoretical Foundation of the Study

The study is grounded in a layered theoretical foundation because BIM adoption in construction organizations cannot be explained adequately through a single theoretical lens. At the broadest level, the Technology, Organization, and Environment framework provides the general architecture for explaining organizational technology adoption through technological conditions, organizational attributes, and environmental influences (Tornatzky & Fleischer, 1990; Baker, 2012). Within that architecture, Institutional Theory provides a more specific explanation of how environmental pressures shape organizational behavior through mimetic, coercive, and normative mechanisms (DiMaggio & Powell, 1983). A further theoretical layer

is required to justify Corporate Culture as a moderating variable, because culture affects how organizations interpret and respond to external expectations rather than functioning only as another direct antecedent (Bogale & Debela, 2024; Behl et al., 2022; Dai et al., 2018), as shown in Table 10.

Table 10: Theoretical foundations underpinning the study

Theory / framework	Core theoretical focus	Relevance to the present study	Variables / relationships explained	Key sources
Technology, Organization, and Environment framework	Explains organizational adoption of innovation through technological, organizational, and environmental contexts	Provides the overarching structure for explaining BIM adoption at the organizational level	Complexity, Relative Advantages, Compatibility, Top Management Support, Organizational Readiness, Mimetic Pressures, Coercive Pressures, Normative Pressures, and BIM adoption	Tornatzky and Fleischer (1990); Baker (2012); Wang et al. (2025)
Institutional Theory	Explains how organizational behavior is associated with legitimacy demands and institutional pressures in the external environment	Provides the specific theoretical basis for environmental pressures affecting BIM adoption	Mimetic Pressures, Coercive Pressures, and Normative Pressures	DiMaggio and Powell (1983); Tavallaei et al. (2022); Salem et al. (2025)
Organizational culture perspective	Explains how shared values, beliefs, norms, and assumptions shape organizational interpretation and action	Provides the basis for modeling Corporate Culture as a focused internal conditioning mechanism	Corporate Culture as a moderator of the relationship between Normative Pressures and BIM adoption	Bogale and Debela (2024); Alankarage et al. (2023); Behl et al. (2022); Dai et al. (2018)

2.3.1. Technology, Organization, and Environment Framework

The Technology, Organization, and Environment framework was introduced to explain how organizations adopt technological innovations by considering three contextual dimensions, namely the technological context, the organizational context, and the environmental context (Tornatzky & Fleischer, 1990; Baker, 2012). The technological context refers to the characteristics of the innovation and the technologies available to the firm. The organizational context refers to internal resources, structures, managerial processes, and readiness conditions. The environmental context refers to competitors, clients, industry

conditions, institutional expectations, and other external forces that shape organizational decision making (Baker, 2012; Oliveira & Martins, 2011).

The TOE framework is particularly suitable for BIM adoption because BIM is not an individual acceptance event. It is an organizational-level innovation that requires firms to assess technological feasibility, internal preparedness, and environmental expectations simultaneously (Chowdhury et al., 2024; Wang et al., 2025).

2.3.2. Institutional Theory and Environmental Pressures

Although TOE identifies the environment as a critical dimension of organizational adoption, it does not by itself explain the mechanisms through which environmental forces influence organizations. Institutional Theory addresses that issue by explaining how organizations respond to pressures for legitimacy and conformity within their organizational fields (DiMaggio & Powell, 1983). DiMaggio and Powell (1983) distinguished three major forms of institutional pressure: mimetic pressure, coercive pressure, and normative pressure.

This theoretical lens is highly relevant to BIM adoption because BIM often spreads through client requirements, market visibility, industry expectations, and professional discourse rather than through technological merit alone (Tavallaei et al., 2022; Salem et al., 2025). Institutional Theory therefore provides the specific explanatory basis for the environmental dimension of the present model, as shown in Table 11.

Table 11: Institutional Theory and the environmental variables of the study

Environmental variable	Institutional meaning	Mechanism of influence	Relevance to BIM adoption	Key sources
Mimetic Pressures	Pressure to imitate successful or legitimate peers under uncertainty	Organizations copy the visible practices of other firms	Firms may adopt BIM when competitors, consultants, or project partners are seen to benefit from it	DiMaggio and Powell (1983); Wang et al. (2025)
Coercive Pressures	Pressure arising from formal authority, dependency, and external requirements	Organizations respond to mandates, client requirements, procurement conditions, or other powerful expectations	Firms may adopt BIM because of government, client, or major contractor demands	DiMaggio and Powell (1983); Salem et al. (2025)
Normative Pressures	Pressure arising from professional norms, standards, and accepted	Organizations align with evolving professional values	Firms may adopt BIM because BIM is increasingly viewed as the modern and	DiMaggio and Powell (1983); Tavallaei et al.

Environmental variable	Institutional meaning	Mechanism of influence	Relevance to BIM adoption	Key sources
	expectations of appropriate practice	and field-wide legitimacy standards	professionally appropriate way of working	(2022); Salem et al. (2025)

2.3.3. Theoretical Justification for Corporate Culture as a Moderating Variable

The theoretical justification for Corporate Culture as a moderating variable rests on the argument that organizations do not interpret external pressures in a culturally neutral way. Corporate Culture shapes what organizational members regard as legitimate, meaningful, and worthy of action, and therefore influences how external expectations are translated into internal organizational responses (Bogale & Debela, 2024). BIM-specific studies show that culture is an essential element in BIM-related organizational and professional change, and that BIM practices in contractor organizations reflect deeper assumptions and beliefs rather than formal procedures alone (Alankarage et al., 2023; Alankarage et al., 2024).

The broader innovation and strategy literature provides stronger direct support for treating culture as a moderator. Behl et al. (2022) found that organizational culture played a critical moderating role in the adoption of artificial intelligence for disaster relief operations. Dai et al. (2018) likewise found that organizational culture moderated the relationship between market pressures and proactive environmental strategy. These studies support the idea that culture can alter the strength of the relationship between external pressures and organizational outcomes, as shown in Table 12.

Table 12: Theoretical justification for Corporate Culture as a moderating variable

Element	Explanation	Theoretical logic	Key sources
Normative Pressures	Reflect professional norms, accepted standards, and shared expectations of appropriate organizational behavior	Normative pressures operate through values, legitimacy, and professionalized expectations	DiMaggio and Powell (1983); Tavallaei et al. (2022); Salem et al. (2025)
Corporate Culture	Reflects the internal system of shared values, beliefs, assumptions, and norms within the organization	Culture shapes how external expectations are interpreted, accepted, resisted, or translated into action	Bogale and Debela (2024); Alankarage et al. (2024)
Moderating logic	The relationship between Normative Pressures on BIM adoption becomes stronger or	Both constructs are linked to legitimacy, values, and accepted	Behl et al. (2022); Dai et al. (2018); Tavallaei et al. (2022)

Element	Explanation	Theoretical logic	Key sources
	weaker depending on the prevailing Corporate Culture	behavior, making moderation theoretically plausible	
Boundary of moderation	Corporate Culture does not moderate all TOE relationships	The moderation is restricted to the Normative Pressures → BIM adoption path because this is the most conceptually defensible relationship	DiMaggio and Powell (1983); Bogale and Debela (2024); Tavallaei et al. (2022)

2.3.4. Theoretical Anchoring of the Study Variables

The final model of the study is theoretically anchored in a way that preserves internal coherence across all variables. BIM adoption is treated as the dependent variable and is positioned as an organizational innovation outcome. Complexity, Relative Advantages, and Compatibility are anchored in the technological dimension because they represent the organization's evaluation of BIM in terms of difficulty, benefit, and fit. Top Management Support and Organizational Readiness are anchored in the organizational dimension because they represent internal commitment, preparedness, and implementation capacity. Mimetic, Coercive, and Normative Pressures are anchored in the environmental dimension because they capture the institutional mechanisms through which the external field shapes adoption behavior (Baker, 2012; DiMaggio & Powell, 1983; Wang et al., 2025).

Corporate Culture is anchored differently from the direct antecedents because its role in this study is conditional rather than universal. On that basis, Corporate Culture is theoretically anchored as a moderator of the relationship between Normative Pressures and BIM adoption only.

2.4. Technological Factors

Technological factors are fundamental to BIM adoption because organizations evaluate BIM as an innovation with particular characteristics that affect its perceived feasibility, usefulness, and fit with existing work systems (Chowdhury et al., 2024; Wang et al., 2025). In the BIM literature, this logic is especially important because BIM adoption is not a simple software purchase. It is an organizational decision involving process change, coordination demands, information management requirements, and technical integration across multiple actors and workflows (Chowdhury et al., 2024).

2.4.1. Complexity

Complexity is one of the most frequently discussed technological attributes in BIM adoption research because organizations evaluate BIM not only in terms of expected benefits, but also in terms of the demands associated with understanding, integration, coordination, and operational handling in practice (Ullah et al., 2022; Tan et al., 2025). In the BIM context, complexity extends beyond software difficulty alone. It includes the demands of process redesign, role adjustment, model coordination, interoperability management, training, and cross-organizational collaboration, which means that BIM-related complexity is embedded in broader organizational practice rather than in technical use alone (Liao et al., 2022; El Masry & Chron er, 2025). For this reason, complexity remains a relevant technological consideration in BIM adoption research, particularly in construction settings where technological change affects multiple actors, workflows, and decision points simultaneously (Chowdhury et al., 2024).

The empirical literature confirms that BIM-related complexity represents a meaningful challenge for organizations. Ullah et al. (2022) found that complexity in both system development and system use was relevant to BIM-related adoption processes. Liao et al. (2022) likewise concluded that complexity issues in BIM diffusion are multidimensional, while recent literature on BIM resistance reinforces the view that complexity can become a practical burden when organizations perceive BIM as difficult to absorb or difficult to align with existing routines (Tan et al., 2025). However, the present study does not treat TCO as complexity in the sense of a purely inhibiting barrier. Rather, TCO in the present study refers to the perceived manageability of BIM-related complexity within the organization. In this sense, the focus is not simply on whether BIM carries demands, but on whether those demands are viewed as understandable, coordinable, and manageable in organizational practice.

Accordingly, the present study treats TCO as the organization's evaluation of whether BIM-related complexity can be handled without excessive disruption or burden. Under this interpretation, stronger perceived manageability of BIM-related complexity is expected to be associated with stronger BIM adoption, because organizations are more likely to move toward formal and continuing BIM uptake when the practical demands of BIM are viewed as manageable rather than prohibitive. This interpretation preserves the importance of complexity in the technological dimension of the model while aligning the construct more closely with the study's current operationalization and empirical logic (Ullah et al., 2022; Liao et al., 2022; Chowdhury et al., 2024).

2.4.2. Relative Advantages

Relative Advantages refer to the extent to which BIM is perceived as offering superior benefits compared with traditional approaches to design, coordination, communication, and project information management (Murguia et al., 2023; Wang, Guo, Di Sarno, & Sun, 2024). In BIM research, these advantages are commonly associated with better project coordination, stronger visualization, improved information consistency, enhanced decision support, and superior project delivery outcomes (Chowdhury et al., 2024; Murguia et al., 2023).

The empirical literature provides direct support for the positive role of Relative Advantages. Murguia et al. (2023) found that contractors adopted BIM when they believed BIM improved project performance rather than merely individual user performance. Meta-analytic evidence likewise shows that performance-related benefit beliefs remain among the most influential drivers of BIM acceptance and adoption (Wang, Guo, Di Sarno, & Sun, 2024).

2.4.3. Compatibility

Compatibility refers to the extent to which BIM is perceived as fitting existing organizational routines, technical systems, workflows, and operational needs (Shirowzhan et al., 2020). In the BIM literature, compatibility is especially important because organizations do not adopt BIM in an empty environment. They evaluate whether BIM can be aligned with existing practices and whether the changes required for implementation are manageable (Shirowzhan et al., 2020; El Masry & Chronéer, 2025).

A major contribution of the compatibility literature is the clarification that compatibility is not the same as interoperability. Compatibility concerns the broader organizational and contextual fit of BIM, whereas interoperability concerns technical data exchange and system interaction (Shirowzhan et al., 2020). The literature supports a positive link between compatibility and BIM adoption because stronger perceived fit reduces disruption and increases the practical viability of implementation.

2.4.4. Synthesis of Technological Factors

Taken together, the literature shows that technological factors influence BIM adoption through three distinct but complementary evaluative pathways. TCO reflects the extent to which BIM-related complexity is perceived as manageable within the organization. TRA reflects the extent to which BIM is perceived as offering meaningful advantages over traditional methods. TCOM reflects the extent to which BIM is perceived as fitting the organization's existing systems, workflows, and operating conditions (Ullah et al., 2022;

Murguia et al., 2023; Shirowzhan et al., 2020). In this sense, the technological dimension of the present study is not limited to the presence of technological demands alone. Rather, it addresses whether BIM is sufficiently manageable, beneficial, and compatible to support organizational BIM adoption in construction practice (Chowdhury et al., 2024; Wang et al., 2025).

The overall technological logic of the model is therefore that organizations are more likely to move toward BIM adoption when BIM-related complexity is perceived as manageable, when BIM is perceived as offering meaningful improvement over traditional practices, and when BIM is perceived as fitting the organization's routines and systems. On that basis, the present study retains TCO, TRA, and TCOM as the three core technological antecedents of BIM adoption in the Libyan construction sector (Ullah et al., 2022; Murguia et al., 2023; Shirowzhan et al., 2020; Chowdhury et al., 2024; Wang et al., 2025).

2.5. Organizational Factors

The organizational dimension is central to BIM adoption because firms do not adopt BIM on the basis of technological characteristics alone. They also adopt or resist BIM according to their internal capacity to authorize change, mobilize resources, support learning, and institutionalize new working practices (Chowdhury et al., 2024; Wang et al., 2025).

2.5.1. Top Management Support

Top Management Support is widely recognized as one of the most important organizational conditions affecting BIM adoption because senior leaders shape strategic priorities, allocate resources, authorize change, and provide legitimacy for implementation efforts inside the firm (Tavallaei et al., 2022; Villena-Manzanares et al., 2021).

The BIM literature provides direct support for the positive influence of Top Management Support. Tavallaei et al. (2022) showed that this variable forms part of the internal mechanism through which external pressures are translated into adoption behavior. Villena-Manzanares et al. (2021) likewise found that senior management support is linked to BIM effectiveness through collaborative culture and technological learning.

2.5.2. Organizational Readiness

Organizational Readiness is a major organizational factor because firms may recognize BIM's benefits while still lacking the internal capability to adopt it effectively (Magalhães et al., 2023; Ndwandwe et al., 2024). In the BIM literature, readiness generally refers to the extent

to which an organization possesses the awareness, competence, structure, process capacity, technological support, and implementation conditions needed to begin and sustain BIM adoption (Phung & Tong, 2021; Magalhães et al., 2023).

Recent studies provide strong support for the role of readiness. Ndwandwe et al. (2024) reported that organizations possessed BIM-capable software, yet readiness remained limited because competence levels were still insufficient for strong implementation. Conceptual and framework-oriented studies reinforce the same conclusion by treating readiness as a multidimensional organizational state of preparedness rather than as a single skill or resource variable (Magalhães et al., 2023; Phung & Tong, 2021).

2.5.3. Synthesis of Organizational Factors

The literature reviewed above shows that organizational factors affect BIM adoption through two closely related but distinct pathways. Top Management Support captures the organization's willingness to authorize and champion BIM, while Organizational Readiness captures the organization's ability to operationalize BIM in practice (Tavallaei et al., 2022; Magalhães et al., 2023).

This synthesis supports a clear conclusion for the present study. BIM adoption is more likely when firms are led by senior managers who actively support digital change and when those firms possess sufficient internal readiness in terms of awareness, competence, structure, and process capability (Rajabi et al., 2022; Wang et al., 2025).

2.6. Environmental Factors

Environmental factors are central to BIM adoption because organizations do not make adoption decisions in isolation. Rather, they respond to external institutional conditions, industry expectations, stakeholder demands, and legitimacy pressures that shape what is considered appropriate behavior in the construction field (DiMaggio & Powell, 1983; Chowdhury et al., 2024). Within the BIM literature, these external influences are commonly conceptualized through institutional theory as Mimetic, Coercive, and Normative Pressures (Cao et al., 2014; Tavallaei et al., 2022).

2.6.1. Mimetic Pressures

Mimetic Pressures refer to the tendency of organizations to imitate other organizations that are perceived as successful, legitimate, or strategically advanced, especially under conditions of uncertainty (DiMaggio & Powell, 1983). In the context of BIM adoption, mimetic

pressure arises when firms observe competitors, leading contractors, consultants, or project partners using BIM and then interpret imitation as a rational response to market uncertainty and competitive pressure (Cao et al., 2014; Tavallaei et al., 2022).

The empirical literature provides substantial support for the positive role of Mimetic Pressures in BIM adoption. Cao et al. (2014) found that mimetic pressure is significantly associated with BIM adoption in construction projects. More recent evidence from the MENA region and Nigerian SMEs points in the same direction (Salem et al., 2025; Saka et al., 2024).

2.6.2. Coercive Pressures

contractual requirements, or regulatory expectations imposed by powerful actors such as governments, clients, major contractors, or public agencies (DiMaggio & Powell, 1983). In BIM research, coercive pressure is typically associated with mandates, procurement requirements, client specifications, and other conditions that alter the consequences of non-adoption (Cao et al., 2014; Tavallaei et al., 2022). The empirical evidence generally supports a positive relationship between Coercive Pressures and BIM adoption. Cao et al. (2014) found that coercive pressure was significantly associated with BIM adoption in construction projects. Regional evidence from the MENA construction industry likewise confirmed that coercive pressure was significantly associated with BIM-related outcomes among subcontractors (Salem et al., 2025). Taken together, these findings suggest that coercive pressure remains an important environmental predictor of BIM adoption because it links organizational response to formal expectations, dependency structures, and the practical consequences of compliance or non-compliance in the wider construction field (Cao et al., 2014; Salem et al., 2025; Tavallaei et al., 2022).

2.6.3. Normative Pressures

Normative Pressures refer to the influence of professional norms, educational systems, expert discourse, industry associations, and shared expectations regarding what constitutes appropriate and legitimate practice within an organizational field (DiMaggio & Powell, 1983). In the BIM context, normative pressure emerges when professional communities increasingly treat BIM as a modern, credible, and expected way of organizing design, coordination, and information management (Tavallaei et al., 2022; Chowdhury et al., 2024).

Among the three environmental factors, Normative Pressure appears to be especially prominent in the BIM literature. Tavallaei et al. (2022) found that normative pressure was the most prominent institutional pressure affecting organizational BIM adoption across AEC firms. Salem et al. (2025) reinforced this interpretation by showing that normative pressure was significantly associated with BIM awareness, adoption, training, visualization, and productivity in large-scale MENA construction projects. This pattern is theoretically important because normative pressure operates through legitimacy, professional expectations, and accepted understandings of appropriate organizational practice rather than through formal compulsion alone (DiMaggio & Powell, 1983; Tavallaei et al., 2022). On that basis, Normative Pressures are treated in the present study as a central environmental predictor of BIM adoption in the Libyan construction sector.

2.6.4. Synthesis of Environmental Factors

Taken together, the literature shows that environmental factors provide a strong institutional explanation for BIM adoption. Mimetic Pressure encourages adoption by making peer behavior and visible market success influential under uncertainty. Coercive Pressure encourages adoption by linking BIM to compliance, contractual expectations, and dependency relationships with powerful actors. Normative Pressure encourages adoption by presenting BIM as an accepted and professionally legitimate form of contemporary construction practice (Cao et al., 2014; Tavallaei et al., 2022; Salem et al., 2025).

The evidence also suggests that the relative strength of environmental factors is not perfectly uniform across settings. Some studies and synthesis work highlight Mimetic Pressure as a particularly strong external driver, while others identify Normative Pressure as especially prominent in explaining organizational BIM adoption (Tavallaei et al., 2022; Wang et al., 2025).

2.7. Corporate Culture as a Moderating Variable

Corporate Culture occupies a central position in the present study because BIM adoption is not merely a technical or procedural decision. It is an organizational response that depends on how firms interpret external expectations, internalize change, and translate new practices into everyday routines (Bogale & Debela, 2024; Alankarage et al., 2023).

2.7.1. Concept and Dimensions of Corporate Culture

Corporate Culture is generally defined as the shared system of values, beliefs, norms, assumptions, and expected patterns of behavior that guides how members of an organization interpret situations and act within them (Bogale & Debela, 2024; Schein, 2010). In organizational research, culture is not treated as a decorative or symbolic feature of the firm, but as a substantive internal mechanism that influences interpretation, coordination, legitimacy, and action (Bogale & Debela, 2024; Schein, 2010). A foundational explanation of culture's dimensions is provided by Schein's model, which distinguishes between artifacts, espoused values, and basic underlying assumptions (Schein, 2010). This layered understanding has already been shown to be relevant in BIM-related research, where BIM-related organizational behavior is shaped not only by formal processes or technical tools, but also by deeper cultural assumptions embedded in the organization (Alankarage et al., 2024).

2.7.2. Corporate Culture and Organizational Innovation Adoption

The literature consistently shows that Corporate Culture is closely related to organizational innovation adoption because culture shapes how firms interpret new ideas, define acceptable change, and legitimize experimentation inside the organization (Hogan & Coote, 2014; Bogale & Debela, 2024). A supportive culture strengthens innovation adoption by making new practices appear legitimate, workable, and strategically valuable, whereas a rigid or change-resistant culture weakens adoption by preserving the status quo and increasing resistance to organizational transformation (Scaliza et al., 2022; Hasan et al., 2025).

The relationship between Corporate Culture and innovation adoption is also visible in BIM-related and construction-related research. Alankarage et al. (2023) concluded that culture is an essential element in BIM practice, while Tennakoon et al. (2022) found that cultural factors such as coordination and integration, empowerment, and organizational learning strongly influenced knowledge management in BIM-enabled construction environments, as shown in Figure 5.

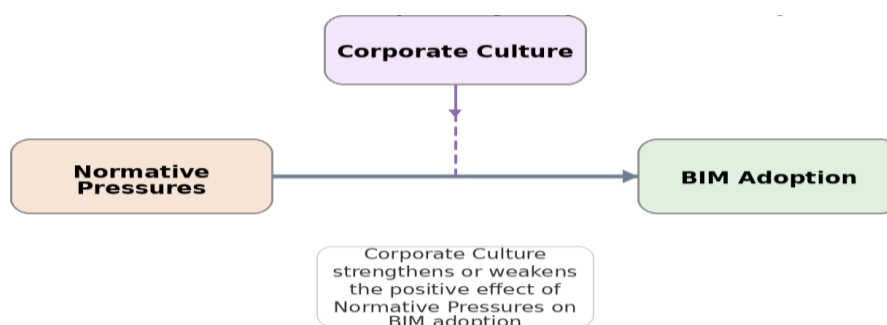


Figure 5. Moderating role of Corporate Culture in the relationship between Normative Pressures and BIM adoption.

Source: Own elaboration based on DiMaggio and Powell (1983), Tavallaei et al. (2022), Bogale and Debela (2024), Behl et al. (2022), and Dai et al. (2018).

2.7.3. Corporate Culture in the Construction Sector

Corporate Culture is particularly important in the construction sector because construction work is executed through coordination-intensive, project-based arrangements in which organizational routines, communication patterns, and shared norms directly affect how teams cooperate and perform (Nguyen & Watanabe, 2017). Empirical research in construction confirms that culture has measurable implications for organizational and project outcomes, and BIM-specific evidence shows that implementation depends heavily on collaboration, knowledge exchange, and learning across organizational boundaries (Nguyen & Watanabe, 2017; Tennakoon et al., 2022; Villena-Manzanares et al., 2021). Recent construction-specific BIM studies reinforce the same conclusion at a deeper organizational level. Alankarage et al. (2024) identified underlying beliefs evident in BIM practices within a contractor organization, showing that BIM-related behavior in construction is rooted in deeper assumptions and not merely in formal procedures or declared intentions.

2.7.4. Why Corporate Culture Moderates the Relationship Between Normative Pressures and BIM Adoption

The moderating role of Corporate Culture in the present study is specified for the relationship between Normative Pressures and BIM adoption because normative pressure operates through professional values, legitimacy, shared expectations, and socially accepted standards of appropriate behavior, all of which are conceptually close to the domain of organizational culture (DiMaggio & Powell, 1983; Tavallaei et al., 2022). Existing BIM evidence supports this logic. Tavallaei et al. (2022) found normative pressure to be especially prominent in explaining organizational BIM adoption, and Salem et al. (2025) further showed that normative pressure was significantly associated with BIM-related outcomes in large-scale MENA construction projects. The broader organizational literature provides direct support for treating culture as a moderator rather than only as a direct predictor. Behl et al. (2022) and Dai et al. (2018) showed that culture can change the strength of the relationship between external pressures and organizational outcomes.

On this basis, the present study argues that stronger Corporate Culture, particularly when it supports learning, innovation, collaboration, and openness to professionally endorsed change, is likely to strengthen the positive relationship between Normative Pressures and BIM adoption. In other words, when organizations possess a more supportive internal culture, professionally endorsed external expectations concerning BIM are more likely to be interpreted positively and translated into stronger organizational movement toward BIM adoption. By contrast, a weak or resistant culture is more likely to limit that relationship by reducing openness to change, weakening internal legitimacy for BIM-related transformation, and constraining the organizational response to external normative expectations (Alankarage et al., 2024; Tennakoon et al., 2022). This is why the present study positions Corporate Culture as a focused moderator of the relationship between Normative Pressures and BIM adoption rather than as a broad moderator across all paths in the model.

2.8. BIM Adoption in Developing Countries and the Libyan Construction Context

The international literature shows that BIM has progressed from being treated as a design-support technology to being understood as a wider organizational and institutional transformation in the architecture, engineering, and construction industry. BIM adoption should therefore be interpreted within a contextual continuum rather than through a single universal trajectory (Chowdhury et al., 2024; Wang et al., 2025).

2.8.1. BIM Adoption in Developed Construction Contexts

The literature generally characterizes developed countries as the earliest and most institutionally prepared environments for BIM diffusion. What distinguishes these contexts is the existence of stronger implementation infrastructures around BIM, including coordinated government leadership, formal roadmaps, standardized guidance, education and training systems, and a clearer articulation of the business case for adoption (Smith, 2014; Mitera-Kielbasa & Zima, 2024). At the same time, recent reviews caution against idealizing developed contexts, because higher BIM maturity does not eliminate adoption and implementation problems. It instead changes their nature from initial awareness barriers toward deeper issues of organizational transformation and integration (Chowdhury et al., 2024).

2.8.2. BIM Adoption in Developing Countries

The literature indicates that BIM adoption in developing countries has advanced more slowly and less uniformly than in mature construction markets, despite the growing recognition of BIM's potential benefits (Chowdhury et al., 2024; Wang et al., 2025). A recurring finding

in this body of research is that the core problem is not the absence of BIM's promised value, but the difficulty of translating that value into sustained practice under constrained local conditions (Ozcan-Deniz et al., 2025). The constraints most frequently reported include economic pressure, high implementation costs, weak standardization, limited technical expertise, insufficient organizational readiness, and the absence of clear implementation pathways, while the most frequently reported enablers include visible project benefits, senior management support, stronger knowledge resources, standardized data structures, and clearer client or institutional demand (Akal et al., 2022; Ndwandwe et al., 2024; Adetoro et al., 2025).

2.8.3. BIM Adoption Challenges in Arab and MENA Construction Contexts

The Arab and MENA construction context occupies an important intermediate position in the BIM literature. The regional evidence shows a mixed landscape in which some jurisdictions have introduced visible BIM initiatives or mandates, while much of the broader construction field still struggles with uneven diffusion, inconsistent standards, limited technical capacity, and fragmented implementation practices (El Hajj et al., 2023; Salem et al., 2025).

Across multiple Arab and MENA settings, recurring barriers include low awareness, weak technical expertise, high software and training costs, lack of standards and implementation guidelines, limited client demand, resistance to change, traditional contracting systems, and insufficient managerial or policy support (El Hajj et al., 2023; Al Aamri et al., 2025; Hyarat et al., 2022; Al-Raqeb et al., 2024).

2.8.4. The Libyan Construction Sector as the Context of the Study

The Libyan construction sector represents a context in which the need for stronger project coordination, information accuracy, and managerial control is evident, while the institutionalization of digital construction methods remains limited (Shebob et al., 2012). The Libya-specific BIM literature remains limited when compared with the evidence available for more mature or more widely studied construction markets. Available studies nevertheless indicate growing practical interest in BIM in Libya. Elghdban et al. (2023) investigated BIM adoption in Libyan construction firms at the organizational level. Other Libya-focused studies connect BIM with risk and change management, worker safety, and cost estimation improvement (Elfargani, 2022; Al-Khabi & Al-Huni, 2025; Solla et al., 2025). These findings suggest that Libya is a relevant yet underexamined context in which BIM adoption is associated with interacting technological, organizational, environmental, and cultural factors.

2.9. Empirical Synthesis and Research Gap

The preceding review shows that BIM adoption has been examined through a wide range of technological, organizational, and environmental perspectives, yet the accumulated evidence remains fragmented across contexts, levels of analysis, and theoretical traditions (Chowdhury et al., 2024; Wang et al., 2025). Recent BIM scholarship indicates that earlier studies often emphasized isolated predictors of adoption, whereas more recent work has called for a more integrated understanding that connects technological attributes, organizational capabilities, and institutional pressures within a single explanatory structure (Tavallaei et al., 2022). This issue is particularly important because BIM adoption is not associated with one factor alone, and firms typically respond to the combined effects of perceived technological fit, internal organizational preparedness, and external pressures from the broader construction environment (Wang et al., 2025). The empirical literature also shows that, although there is substantial support for the importance of TOE-related factors, the strength and significance of individual relationships are not always consistent across countries, types of firms, and stages of BIM implementation (Chowdhury et al., 2024; Wang et al., 2025). Moreover, institutional theory-based BIM studies have demonstrated that mimetic, coercive, and normative pressures influence organizational BIM adoption, but they also suggest that internal organizational conditions remain essential in determining whether those external pressures are converted into actual adoption behavior (Tavallaei et al., 2022; Salem et al., 2025). This is where an important gap emerges in the prior literature. While normative pressure has already been shown to be a meaningful predictor of BIM-related organizational outcomes, much less attention has been given to the internal organizational conditions that may strengthen or weaken its effect in specific construction contexts (Tavallaei et al., 2022; Salem et al., 2025).

In addition, the broader organizational literature suggests that corporate culture can shape how external expectations are interpreted and enacted, yet this moderating logic has not been sufficiently integrated into BIM adoption models in a focused and context-specific way (Bogale & Debela, 2024; Behl et al., 2022). Accordingly, this section synthesizes the empirical evidence on technological, organizational, and environmental predictors of BIM adoption, identifies the principal areas of convergence and inconsistency in prior studies, and clarifies the research gap that justifies the current study (Chowdhury et al., 2024; Wang et al., 2025). It also positions the present research by showing that its contribution lies not only in examining BIM adoption in the Libyan construction sector, but also in specifying corporate culture as a

moderator of the relationship between normative pressures and BIM adoption (Tavallaei et al., 2022; Bogale & Debela, 2024).

2.9.1. Empirical Evidence on Technological Factors and BIM Adoption

The empirical literature consistently shows that technological factors remain central to explaining BIM adoption, although the strength of individual technological effects varies across contexts and levels of analysis (Chowdhury et al., 2024). Technological explanations are especially prominent in BIM studies because organizations typically evaluate BIM first as an innovation with specific characteristics, including difficulty of implementation, expected benefits, and fit with existing systems and workflows (Wang et al., 2024). At the same time, recent reviews caution that technological factors should not be interpreted in isolation, because their effect on BIM adoption is often filtered through organizational and environmental conditions (Chowdhury et al., 2024; Wang et al., 2025).

Among the technological factors examined in prior BIM research, complexity has repeatedly emerged as an important barrier to adoption. Ullah et al. (2022) found that complexity in both system development and system use affected adoption in the BIM-based building permit process, indicating that organizations may hesitate when implementation is perceived as difficult and resource demanding (Ullah et al., 2022). More recent research on BIM resistance has reinforced this interpretation by showing that perceived implementation difficulty can generate resistance across multiple stages of the innovation process rather than only at the initial decision stage (Tan et al., 2025). These findings suggest that complexity is best understood as a negative technological condition that reduces adoption propensity when BIM is perceived as difficult to understand, integrate, or sustain in practice (Ullah et al., 2022; Tan et al., 2025).

By contrast, relative advantages are generally associated with stronger BIM adoption because organizations are more willing to adopt BIM when they perceive that it improves project performance, coordination, and decision-making compared with traditional methods (Murguia et al., 2023). Longitudinal evidence from Peru shows that contractors were more likely to adopt BIM when they believed that BIM improved project performance rather than only individual user performance (Murguia et al., 2023). In a broader meta-analytic synthesis, Wang et al. (2024) also found that performance expectancy, perceived value, and related benefit-oriented constructs were among the strongest factors associated with BIM adoption (Wang et al., 2024). This pattern indicates that organizations do not adopt BIM merely because

it is available, but because they judge it to offer superior value over conventional project delivery and information-management approaches (Murguia et al., 2023; Wang et al., 2024).

Compatibility likewise occupies an important position in the technological literature because firms are more likely to adopt BIM when it is perceived as fitting existing organizational practices, digital systems, and project workflows (Shirowzhan et al., 2020). A major contribution of the compatibility literature has been to distinguish compatibility from interoperability, showing that technical data exchange alone does not guarantee that BIM fits the organization's operational context (Shirowzhan et al., 2020). This distinction is analytically important because many adoption difficulties arise not simply from software limitations, but from weak alignment between BIM requirements and the routines, structures, and information practices of the adopting organization (Shirowzhan et al., 2020). Accordingly, the empirical evidence on compatibility suggests that adoption becomes more likely when BIM is perceived as organizationally and technically alignable with existing practices (Shirowzhan et al., 2020).

Overall, the technological evidence reviewed above points to a relatively clear pattern. Complexity tends to constrain BIM adoption, whereas relative advantages and compatibility tend to support it (Ullah et al., 2022; Murguia et al., 2023; Shirowzhan et al., 2020). However, the literature also suggests that these technological variables do not operate uniformly across all contexts, because their influence depends partly on the organizational capabilities and environmental conditions surrounding adoption (Chowdhury et al., 2024; Wang et al., 2025). This synthesis therefore supports the inclusion of complexity, relative advantages, and compatibility in the present study while also justifying the need to examine them within a broader TOE-based framework in the Libyan construction sector (Chowdhury et al., 2024; Wang et al., 2025).

2.9.2. Empirical Evidence on Organizational Factors and BIM Adoption

The empirical literature indicates that organizational factors are among the most influential predictors of BIM adoption because the decision to adopt BIM is not associated with technological attributes alone, but also by the internal ability of firms to authorize, support, and sustain implementation (Chowdhury et al., 2024). Recent BIM scholarship increasingly treats adoption as an organizational transformation process rather than a purely technical choice, which makes internal conditions such as leadership commitment and organizational preparedness especially important (Chowdhury et al., 2024; Wang et al., 2025). In this respect, the accumulated evidence shows that top management support and organizational readiness are

repeatedly associated with stronger BIM adoption outcomes across different construction contexts (Tavallaei et al., 2022; Ndwandwe et al., 2024).

Top management support has been widely identified as a decisive organizational factor because senior leaders influence strategic direction, resource allocation, change legitimacy, and the prioritization of digital transformation initiatives within the firm (Tavallaei et al., 2022). In a BIM-specific organizational study, Tavallaei et al. (2022) found that top management support significantly associated with BIM adoption, and they further showed that its role varied across different AEC business types while remaining central to the overall adoption process (Tavallaei et al., 2022). Their findings are particularly important because they demonstrate that institutional pressures do not translate automatically into adoption unless internal managerial commitment is present to interpret and operationalize those external signals (Tavallaei et al., 2022). This suggests that leadership support functions as an internal conversion mechanism through which BIM becomes a strategic organizational priority rather than a marginal technical initiative (Tavallaei et al., 2022).

The importance of top management support is reinforced by studies that link leadership commitment to BIM-related effectiveness and capability development. Villena-Manzanares et al. (2021) found that senior management support had direct and indirect effects on BIM effectiveness, partly through its contribution to technological learning and collaborative culture (Villena-Manzanares et al., 2021). Their results are analytically significant because they show that management support does not matter only at the initial decision stage, but continues to shape implementation quality and organizational learning after adoption begins (Villena-Manzanares et al., 2021). This evidence supports the broader argument that BIM adoption is more likely in firms where senior leaders actively define the change agenda, coordinate resources, and maintain organizational commitment throughout the implementation process (Villena-Manzanares et al., 2021; Chowdhury et al., 2024).

Organizational readiness represents the second major organizational factor highlighted in the empirical literature. Organizational readiness is generally understood as the extent to which the firm possesses the awareness, competence, structures, and resources required to begin and sustain BIM implementation (Magalhães et al., 2023). This factor is particularly important because organizations may recognize BIM as beneficial while still remaining unable to adopt it effectively if they lack sufficient preparedness in terms of skills, processes, and implementation capacity (Ndwandwe et al., 2024). In this sense, organizational readiness

bridges the gap between intention and execution by determining whether the firm is capable of converting interest in BIM into operational practice (Rajabi et al., 2022).

Recent empirical studies provide strong support for this interpretation. Ndwandwe et al. (2024), in their study of BIM implementation in Malawi, showed that organizational readiness can be meaningfully assessed through awareness and competence, and they found that although some firms possessed BIM-capable software, low employee competency remained a major limitation to wider implementation (Ndwandwe et al., 2024). This finding is important because it suggests that readiness is not achieved through technology access alone, but depends on the organization's deeper capacity to use BIM effectively (Ndwandwe et al., 2024). Similarly, Rajabi et al. (2022) argued that many BIM benefits remain unrealized because organizations lack the internal capabilities needed for implementation, and their study identified underlying factors and strategies necessary for strengthening organizational BIM capabilities (Rajabi et al., 2022). Together, these findings indicate that BIM adoption becomes more likely when organizations possess stronger capability foundations, higher internal preparedness, and a clearer implementation structure (Rajabi et al., 2022; Ndwandwe et al., 2024).

The literature also shows that organizational readiness is multidimensional rather than narrow. Phung and Tong (2021) proposed an organizational readiness framework for BIM implementation in large design companies and identified strategy, organizational structure, process, people, technology, and information management as major readiness dimensions (Phung & Tong, 2021). This contribution is significant because it clarifies that readiness should not be reduced to training or software alone, and instead reflects a broader institutional preparedness within the firm (Phung & Tong, 2021). Magalhães et al. (2023) likewise conceptualized organizational readiness as the pre-implementation condition representing the organization's propensity to adopt BIM workflows, tools, and protocols (Magalhães et al., 2023). This strengthens the present study's use of organizational readiness as an antecedent of BIM adoption because it locates readiness before implementation and treats it as a necessary enabling condition for the adoption decision itself (Magalhães et al., 2023).

Taken together, the empirical evidence on organizational factors points to a clear pattern. Top management support contributes to BIM adoption by providing legitimacy, direction, and sustained implementation backing (Tavallaei et al., 2022; Villena-Manzanares et al., 2021). Organizational readiness contributes to BIM adoption by ensuring that the firm

has the internal awareness, competence, structure, and process capacity needed to operationalize BIM meaningfully (Ndwandwe et al., 2024; Magalhães et al., 2023). Although the strength of these effects may vary across countries and organizational settings, the overall literature strongly supports the inclusion of both variables in BIM adoption models at the organizational level (Wang et al., 2025). Therefore, the empirical synthesis reviewed in this subsection justifies the inclusion of top management support and organizational readiness as core organizational antecedents of BIM adoption in the current study (Chowdhury et al., 2024; Wang et al., 2025).

2.9.3. Empirical Evidence on Environmental Factors and BIM Adoption

The empirical literature indicates that environmental factors are critical to BIM adoption because organizations do not make adoption decisions in isolation, and instead respond to institutional conditions, market expectations, and field-level pressures operating in the external environment (DiMaggio & Powell, 1983). In BIM research, these environmental influences are commonly conceptualized as mimetic, coercive, and normative pressures, each of which captures a different mechanism through which the institutional environment shapes organizational behavior (Tavallaei et al., 2022). Recent synthesis studies also indicate that the environmental dimension remains an essential part of BIM adoption models, even when technological and organizational factors are also included (Wang et al., 2025). Accordingly, the empirical evidence suggests that environmental pressures help explain why BIM adoption diffuses unevenly across organizations, sectors, and national contexts (Chowdhury et al., 2024).

Mimetic pressure has been widely discussed in the BIM literature as a mechanism through which organizations imitate peer firms or leading actors when they face uncertainty regarding technology adoption (Cao et al., 2014). This logic is consistent with institutional theory, which argues that organizations often model themselves on other organizations perceived as successful or legitimate in order to reduce uncertainty and strengthen legitimacy (DiMaggio & Powell, 1983). In the BIM context, this means that firms may move toward adoption when they observe competitors, market leaders, or project partners using BIM in visible and strategically advantageous ways (Tavallaei et al., 2022). Empirically, Cao et al. (2014) found that mimetic pressure had a significant positive effect on BIM adoption in construction projects, thereby showing that imitation is an active institutional mechanism in BIM diffusion (Cao et al., 2014). More recent evidence confirms this pattern, as Tavallaei et al. (2022) reported that mimetic pressure significantly associated with the organizational level

of BIM adoption across AEC firms (Tavallaei et al., 2022). Salem et al. (2025) also found that mimetic pressure significantly associated with BIM deployment in large-scale construction projects in the MENA region, which is especially relevant to the present study because it reflects a regionally proximate construction environment (Salem et al., 2025). In addition, the recent TOE-based meta-analysis by Wang et al. (2025) concluded that mimetic pressure stood out as a primary external driver in promoting BIM adoption (Wang et al., 2025). Taken together, these findings indicate that organizations are more likely to adopt BIM when peer behavior and field-level visibility make imitation appear strategically rational (Cao et al., 2014; Tavallaei et al., 2022; Salem et al., 2025).

Coercive pressure constitutes the second major environmental factor and refers to the influence exerted by actors that possess regulatory authority, contractual leverage, or other forms of institutional power (DiMaggio & Powell, 1983). In BIM studies, coercive pressure usually arises from governments, public-sector mandates, project owners, major clients, or powerful contractors that require or strongly encourage BIM use as part of procurement, compliance, or project-delivery expectations (Tavallaei et al., 2022; Salem et al., 2025). The empirical evidence suggests that coercive pressure can significantly increase BIM adoption because it changes the consequences of non-adoption by making delay or refusal less viable in institutional and commercial terms (Cao et al., 2014). Cao et al. (2014) found that coercive pressure significantly associated with BIM adoption in construction projects, thereby demonstrating that formal and dependency-based pressures can drive organizations toward BIM use (Cao et al., 2014). Tavallaei et al. (2022) further showed that coercive pressure significantly affected top management support for BIM adoption, which indicates that external obligations can penetrate internal organizational decision-making (Tavallaei et al., 2022). Regional evidence from Salem et al. (2025) likewise confirmed that coercive pressure significantly associated with BIM-related outcomes in MENA construction projects (Salem et al., 2025). However, the broader synthesis by Wang et al. (2025) suggests an important nuance, namely that although coercive pressure is a meaningful positive driver, it may not always be as strong as mimetic pressure across the accumulated evidence base (Wang et al., 2025). Even with that nuance, the literature consistently supports the view that coercive pressure remains a significant environmental antecedent of BIM adoption (Cao et al., 2014; Tavallaei et al., 2022; Salem et al., 2025).

Normative pressure is the third environmental factor and refers to the influence of professional norms, expert discourse, educational systems, industry associations, and shared

expectations regarding what constitutes appropriate practice in the construction field (DiMaggio & Powell, 1983). In BIM-related contexts, normative pressure emerges when professional communities increasingly frame BIM as a legitimate, modern, and expected way of organizing design, coordination, and information management (Tavallaei et al., 2022). Among the three institutional pressures, normative pressure appears especially important in BIM research because BIM is often linked not only to efficiency, but also to professional credibility and alignment with industry best practice (Chowdhury et al., 2024). Tavallaei et al. (2022) reported that normative pressure was the prominent institutional pressure influencing the organizational level of BIM adoption across AEC firms, which makes this variable particularly important for the present study (Tavallaei et al., 2022). Their study also found that normative pressure played the most important role in motivating top managers to extend technology use in their organizations (Tavallaei et al., 2022). This finding is reinforced by Salem et al. (2025), who found that normative pressure significantly associated with BIM awareness, adoption, training, visualization, and productivity among subcontractors in large-scale MENA-region construction projects (Salem et al., 2025). Saka et al. (2024) also reported that normative pressure had a strong association with BIM awareness among Nigerian construction SMEs, indicating that professional and sectoral expectations help shape the early cognitive and organizational stages of BIM diffusion (Saka et al., 2024). Collectively, these findings indicate that normative pressure helps drive BIM adoption by making BIM appear professionally legitimate and institutionally appropriate within the construction field (Tavallaei et al., 2022; Salem et al., 2025; Saka et al., 2024).

Taken together, the empirical evidence on environmental factors points to a broadly consistent pattern. Mimetic pressure encourages BIM adoption by making peer behavior and visible success models influential under uncertainty (Cao et al., 2014; Tavallaei et al., 2022). Coercive pressure encourages BIM adoption by linking BIM to compliance, project access, and dependency relationships with powerful actors (Cao et al., 2014; Salem et al., 2025). Normative pressure encourages BIM adoption by presenting BIM as an accepted and expected component of contemporary professional practice (Tavallaei et al., 2022; Salem et al., 2025). Although the relative strength of these three pressures may differ across countries, firm types, and project settings, the overall literature strongly supports the inclusion of all three environmental variables in BIM adoption models (Wang et al., 2025). This synthesis therefore justifies the inclusion of mimetic, coercive, and normative pressures in the present study and

provides a strong basis for examining their effects in the Libyan construction sector (Chowdhury et al., 2024; Wang et al., 2025).

2.9.4. Empirical Evidence on Corporate Culture as a Moderator

The empirical literature suggests that corporate culture is highly relevant to BIM-related organizational change, even though its role has more often been examined as an internal enabling condition than as an explicitly modeled moderator (Alankarage et al., 2023). Recent BIM scholarship shows that BIM adoption is not purely a technological event, but a sociotechnical transformation that affects organizational routines, professional interaction, and collaborative behavior (Chowdhury et al., 2024). In that type of transformation, culture matters because organizations interpret external expectations through internal values, assumptions, and shared ways of working (Bogale & Debela, 2024). This means that the same external pressure may produce different organizational responses depending on whether the prevailing culture supports learning, openness, collaboration, and change or, instead, favors rigidity and routine preservation (Scaliza et al., 2022). Accordingly, the moderator role proposed in the present study is grounded in the empirical view that culture conditions how external signals are translated into organizational adoption behavior (Behl et al., 2022).

Within the BIM literature itself, the strongest direct evidence supports the importance of culture in shaping BIM transformation processes. Alankarage et al. conducted a systematic literature review and concluded that culture is an essential element in BIM practice, arguing that BIM adoption is closely tied to organizational and professional culture change rather than to technical capability alone (Alankarage et al., 2023). This finding is important because it indicates that internal cultural conditions influence whether BIM-related change can progress from technical introduction to organizational embedding (Alankarage et al., 2023). In a later qualitative case study using Schein's model, Alankarage et al. identified underlying beliefs and cultural assumptions evident in BIM practices within a contractor organization, further showing that BIM behavior is linked to deeper organizational meanings and not only to formal procedures (Alankarage et al., 2024). Together, these studies provide BIM-specific support for the argument that culture is not peripheral to adoption, but part of the internal mechanism through which BIM is interpreted, accepted, or resisted (Alankarage et al., 2023; Alankarage et al., 2024).

Additional BIM-related evidence comes from studies on knowledge, coordination, and organizational learning in BIM-enabled environments. Tennakoon et al. found that

organizational culture significantly associated with knowledge management in BIM-enabled construction environments, with factors such as coordination and integration, empowerment, and organizational learning exerting strong effects (Tennakoon et al., 2022). This is highly relevant to the current study because normative pressures can only translate into actual BIM adoption when organizations possess cultural conditions that support knowledge sharing, collective learning, and coordinated behavioral change (Tennakoon et al., 2022). Related BIM research has also shown that collaborative culture contributes to BIM effectiveness and that leadership support becomes more meaningful when it is linked to a culture that encourages technological learning and cooperation (Villena-Manzanares et al., 2021). These findings do not test moderation directly, but they do show that culture shapes the internal pathway through which BIM-related expectations and practices become operationally effective (Tennakoon et al., 2022; Villena-Manzanares et al., 2021).

The broader organizational and innovation literature provides stronger direct support for modeling culture as a moderator. Behl et al. found that organizational culture played a significant moderating role in the adoption of artificial intelligence for disaster relief operations, demonstrating that culture can strengthen or weaken the relationship between adoption-related drivers in complex organizational settings (Behl et al., 2022). Scaliza et al. similarly reported that different cultural types affect the degree to which firms adopt innovation-oriented behaviors, with adhocracy culture encouraging innovation flows and hierarchy culture discouraging them (Scaliza et al., 2022). Dai et al. further showed that organizational culture moderated the relationship between external market pressure and corporate environmental strategy, which is especially relevant because it provides direct evidence that culture can condition how external pressures shape organizational response (Dai et al., 2018). Taken together, these studies support the analytical logic of the present model, namely that external pressures do not exert identical effects across all organizations because internal cultural orientation influences how those pressures are interpreted and enacted (Behl et al., 2022; Dai et al., 2018).

This moderator logic becomes particularly compelling when it is connected to normative pressure in BIM adoption. Tavallaei et al. found that normative pressure was the most prominent institutional pressure affecting BIM adoption across AEC organizations, which means that professional expectations already have a strong direct empirical relationship with BIM adoption (Tavallaei et al., 2022). Salem et al. likewise reported that normative pressure significantly associated with BIM awareness, adoption, training, visualization, and

productivity in large-scale MENA-region construction projects (Salem et al., 2025). These findings are crucial because they establish the first half of the moderator logic, namely that normative pressure matters empirically in BIM settings (Tavallaei et al., 2022; Salem et al., 2025). The second half of the logic comes from the culture literature, which suggests that the relationship between those external professional expectations should become stronger when organizational culture is more supportive of innovation, learning, and collaboration, and weaker when organizational culture is more rigid or resistant to change (Bogale & Debela, 2024; Scaliza et al., 2022). Thus, although direct BIM studies testing corporate culture as a moderator remain limited, the accumulated evidence is sufficient to justify examining corporate culture as a moderator of the relationship between normative pressures and BIM adoption in the current study (Alankarage et al., 2023; Tavallaei et al., 2022).

Overall, the empirical evidence reviewed in this subsection points to two conclusions. First, BIM studies indicate that culture is relevant to BIM-related organizational behavior, capability development, and transformation processes (Alankarage et al., 2023; Tennakoon et al., 2022). Second, broader innovation and organizational research confirms that culture can function as a moderator by conditioning how external pressures affect adoption-related outcomes (Behl et al., 2022; Dai et al., 2018). What remains insufficiently examined, however, is the focused application of this moderation logic to BIM adoption in a context such as the Libyan construction sector, and specifically to the relationship between normative pressures and BIM adoption (Tavallaei et al., 2022; Salem et al., 2025). This gap provides a clear empirical and theoretical basis for the current study's contribution (Bogale & Debela, 2024).

2.9.5. Research Gaps in Prior Studies

Although the existing literature provides substantial evidence that technological, organizational, and environmental factors influence BIM adoption, the body of knowledge remains fragmented in terms of theoretical integration, empirical emphasis, and contextual coverage (Chowdhury et al., 2024; Wang et al., 2025). BIM adoption studies have often examined selected predictors in isolation, whereas more recent reviews argue that adoption should be explained through a more integrated framework that connects technological attributes, organizational capabilities, and institutional pressures (Chowdhury et al., 2024; Wang et al., 2025). This indicates that a first gap in the literature lies in the need for models that combine these dimensions within one coherent explanatory structure rather than treating them as separate lines of inquiry (Chowdhury et al., 2024; Tavallaei et al., 2022).

A second gap concerns contextual concentration. Much of the empirical BIM adoption literature has been produced in settings such as China, selected AEC markets, or other countries where BIM diffusion is already more visible, while comparatively less evidence is available from the Libyan construction sector (Cao et al., 2014; Tavallaei et al., 2022; Salem et al., 2025). Even where developing-country evidence exists, it is concentrated in contexts such as Nigeria, Malawi, or Iran, which means that findings cannot be assumed to transfer directly to Libya without empirical examination (Saka et al., 2024; Ndwandwe et al., 2024; Rajabi et al., 2022). This contextual gap is important because BIM adoption is associated with institutional environments, market conditions, organizational capacity, and professional expectations that vary across national construction sectors (Chowdhury et al., 2024; Wang et al., 2025).

A third gap relates to the internal conditioning mechanisms through which external institutional pressures are translated into actual organizational adoption behavior. BIM-specific studies have shown that mimetic, coercive, and normative pressures are significantly associated with BIM adoption, and Tavallaei et al. (2022) in particular found normative pressure to be especially prominent across AEC organizations (Tavallaei et al., 2022; Salem et al., 2025). However, prior BIM studies have not sufficiently examined why the same normative environment may generate stronger adoption responses in some organizations than in others (Tavallaei et al., 2022; Chowdhury et al., 2024). This suggests that the literature has established the importance of normative pressure, but has not yet fully clarified the internal organizational condition that may amplify or weaken its effect (Salem et al., 2025; Wang et al., 2025).

A fourth gap concerns the role of corporate culture. Broader organizational and innovation studies show that culture can influence how external pressures and innovation-related drivers are interpreted and enacted, and some studies have demonstrated explicit moderating effects of culture in technology and strategy contexts (Behl et al., 2022; Dai et al., 2018; Scaliza et al., 2022). At the same time, BIM studies have shown that culture is relevant to BIM-enabled transformation, knowledge management, and organizational behavior, but they have more often treated culture as a background or enabling condition than as a formally specified moderator in BIM adoption models (Alankarage et al., 2023; Alankarage et al., 2024; Tennakoon et al., 2022). This creates a clear theoretical and empirical gap, namely the limited testing of corporate culture as a moderator in BIM adoption research, particularly in relation to institutional pressures (Alankarage et al., 2023; Bogale & Debela, 2024).

On this basis, the present study addresses the literature gap in two ways. First, it develops an integrated TOE-based BIM adoption model that includes technological, organizational, and environmental predictors in a single framework suited to the Libyan construction sector (Wang et al., 2025; Chowdhury et al., 2024). Second, it extends the existing BIM adoption literature by specifying corporate culture as a moderator of the relationship between normative pressures and BIM adoption, thereby focusing on the institutional pathway where culture is most theoretically relevant (Tavallaei et al., 2022; Bogale & Debela, 2024). In this sense, the study contributes not only by examining an underrepresented national context, but also by refining the explanatory logic of BIM adoption through the interaction between external professional expectations and internal cultural conditions (Salem et al., 2025; Chowdhury et al., 2024).

2.9.6. Positioning of the Current Study

The present study is positioned at the intersection of BIM adoption research, TOE-based technology adoption theory, and institutional analysis of the construction environment (Chowdhury et al., 2024; Wang et al., 2025). It responds to the growing scholarly call for BIM adoption models that move beyond fragmented explanatory approaches and instead integrate technological, organizational, and environmental predictors within one coherent framework (Chowdhury et al., 2024; Tavallaei et al., 2022). In doing so, the study treats BIM adoption as an organizational-level outcome rather than as a purely individual acceptance decision, which is consistent with recent literature that conceptualizes BIM as a systemic and transformative organizational innovation (Murguia et al., 2021; Chowdhury et al., 2024).

More specifically, the study is positioned within the TOE perspective because this framework provides an analytically suitable basis for examining how firms evaluate BIM through technological conditions, internal organizational capacities, and external environmental pressures (Wang et al., 2025; Faiz et al., 2024). The technological dimension is represented by complexity, relative advantages, and compatibility, since these variables capture how firms assess the difficulty, usefulness, and fit of BIM as an innovation (Shirowzhan et al., 2020; Wang et al., 2025). The organizational dimension is represented by top management support and organizational readiness, because BIM adoption requires internal commitment, capability, and preparedness rather than technology acquisition alone (Tavallaei et al., 2022; Ndwandwe et al., 2024). The environmental dimension is represented by mimetic, coercive, and normative pressures, because BIM adoption in construction is associated with

institutional forces arising from competition, dependency, and professional legitimacy within the external field (DiMaggio & Powell, 1983; Tavallaei et al., 2022).

The current study is also positioned as a context-sensitive contribution to BIM adoption research because it focuses specifically on the Libyan construction sector, which remains underrepresented in the empirical BIM literature (Chowdhury et al., 2024; Saka et al., 2024). Although previous studies have examined BIM adoption in contexts such as China, Nigeria, Iran, Malawi, and selected AEC markets, comparatively limited evidence has been produced for Libya despite the importance of contextual institutional and organizational variation in BIM adoption (Cao et al., 2014; Rajabi et al., 2022; Ndwandwe et al., 2024). This makes the present study important not only because it applies an established theoretical structure, but also because it extends BIM adoption research into a national context where empirical evidence remains limited and cannot be safely inferred from other construction environments (Chowdhury et al., 2024; Wang et al., 2025).

A further basis for positioning the current study lies in its treatment of institutional pressure. Existing BIM studies have already established that mimetic, coercive, and normative pressures influence BIM-related organizational behavior (Cao et al., 2014; Tavallaei et al., 2022; Salem et al., 2025). However, the present study gives special analytical attention to normative pressure because prior evidence indicates that it is particularly prominent in explaining BIM adoption across AEC organizations (Tavallaei et al., 2022). Normative pressure is especially relevant in BIM settings because BIM is often legitimized through professional discourse, industry expectations, and evolving standards of appropriate construction practice rather than through regulation or imitation alone (Tavallaei et al., 2022; Gao et al., 2023). By highlighting normative pressure in this way, the present study positions itself to explain not only whether environmental pressure matters, but also which institutional pathway is most important for the proposed theoretical extension (Salem et al., 2025; Tavallaei et al., 2022).

The distinctive contribution of the current study is therefore not merely the inclusion of another contextual variable, but the specification of corporate culture as a moderator of the relationship between normative pressures and BIM adoption (Bogale & Debela, 2024; Tavallaei et al., 2022). This positioning is theoretically deliberate because normative pressure operates through values, legitimacy, and shared expectations, and these are precisely the domains in which organizational culture exerts its strongest influence (DiMaggio & Powell,

1983; Bogale & Debela, 2024). Prior BIM studies have demonstrated that culture matters for BIM-enabled organizational change, BIM knowledge management, and BIM-related professional behavior, yet they have not sufficiently modeled culture as a focused moderating condition within BIM adoption frameworks (Alankarage et al., 2023; Tennakoon et al., 2022). Broader innovation and organizational studies, however, show that organizational culture can moderate the relationship between external pressures and adoption-related drivers on organizational outcomes, which provides strong theoretical support for the moderation logic adopted in this study (Behl et al., 2022; Dai et al., 2018; Scaliza et al., 2022).

Accordingly, the present study is positioned as a focused refinement of prior BIM adoption models rather than as a broad or unfocused extension (Chowdhury et al., 2024; Wang et al., 2025). It does not propose corporate culture as a generalized moderator across all TOE relationships (Bogale & Debela, 2024). Instead, it limits the moderating role of corporate culture to the relationship between normative pressures and BIM adoption, because that is the relationship in which internal cultural interpretation is most conceptually and institutionally meaningful (Tavallaei et al., 2022; Bogale & Debela, 2024). This choice strengthens the conceptual precision of the model and distinguishes the present research from studies that introduce organizational culture in a broad but weakly specified manner (Scaliza et al., 2022; Wang et al., 2025).

Finally, the study is positioned as an integrated, context-specific, and theoretically refined investigation of BIM adoption in the Libyan construction sector (Chowdhury et al., 2024; Wang et al., 2025). It contributes to the literature by combining TOE-based predictors with institutional pressures in one model, by providing evidence from an underexamined national context, and by introducing corporate culture as a moderator of the relationship between normative pressures and BIM adoption (Tavallaei et al., 2022; Bogale & Debela, 2024; Salem et al., 2025). In this way, the study seeks to advance BIM adoption research both empirically and theoretically by clarifying how external professional expectations and internal cultural conditions interact in shaping organizational BIM adoption (Gao et al., 2023; Chowdhury et al., 2024).

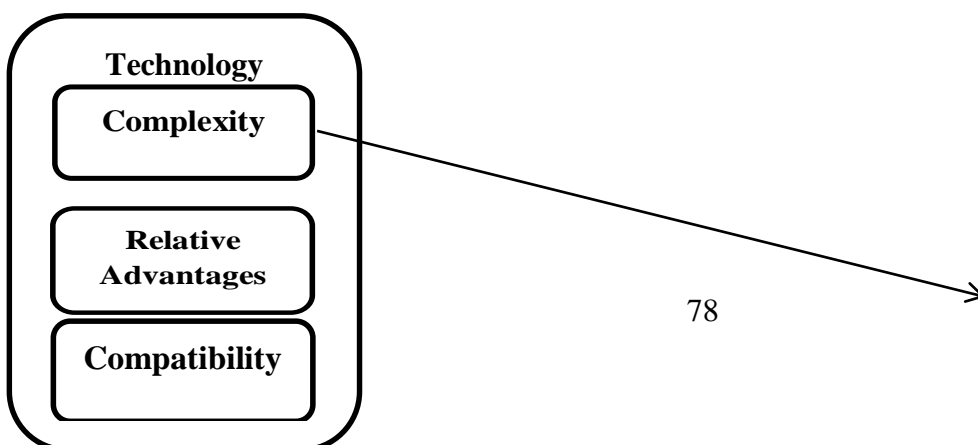
2.10. Conceptual Framework and Hypotheses Development

Based on the preceding theoretical review and empirical synthesis, this section develops the conceptual framework of the study and derives the hypotheses to be tested in the subsequent chapters. The review of prior studies indicates that BIM adoption is not explained by a single

factor, but rather by the interaction of technological conditions, organizational capabilities, and environmental pressures operating within the institutional context of the construction industry. Accordingly, the present study adopts a TOE-based perspective to explain BIM adoption in the Libyan construction sector, while also recognizing the relevance of institutional forces in shaping organizational responses to innovation. On this basis, the conceptual framework specifies BIM adoption as the dependent variable, identifies the key technological, organizational, and environmental antecedents of adoption, and introduces corporate culture as a moderating variable in order to capture the internal organizational condition through which external normative expectations are translated into actual adoption behavior. The section therefore serves two related purposes. First, it presents the conceptual logic of the proposed model. Second, it formulates the research hypotheses in a structured manner that is consistent with the literature reviewed in the previous sections and suitable for empirical testing in the methodology and results chapters.

2.10.1. Conceptual Framework of the Study

The conceptual framework of this study is grounded in the view that BIM adoption is an organizational outcome associated with the interaction of technological attributes, organizational conditions, and environmental pressures rather than by individual preference alone (Chowdhury et al., 2024). This position is consistent with recent BIM scholarship, which has moved away from narrow, technology-centered explanations and toward a more holistic understanding of adoption as a multilevel and transformative process involving organizational structures, implementation environments, and institutional influences (Chowdhury et al., 2024). The framework is also consistent with recent meta-analytic evidence showing that BIM adoption is best explained through an integrated perspective in which technical, organizational, and environmental drivers jointly influence adoption behavior (Wang et al., 2025). Accordingly, the present study adopts the Technology, Organization, and Environment perspective as the main conceptual basis for explaining BIM adoption in the Libyan construction sector (Wang et al., 2025).



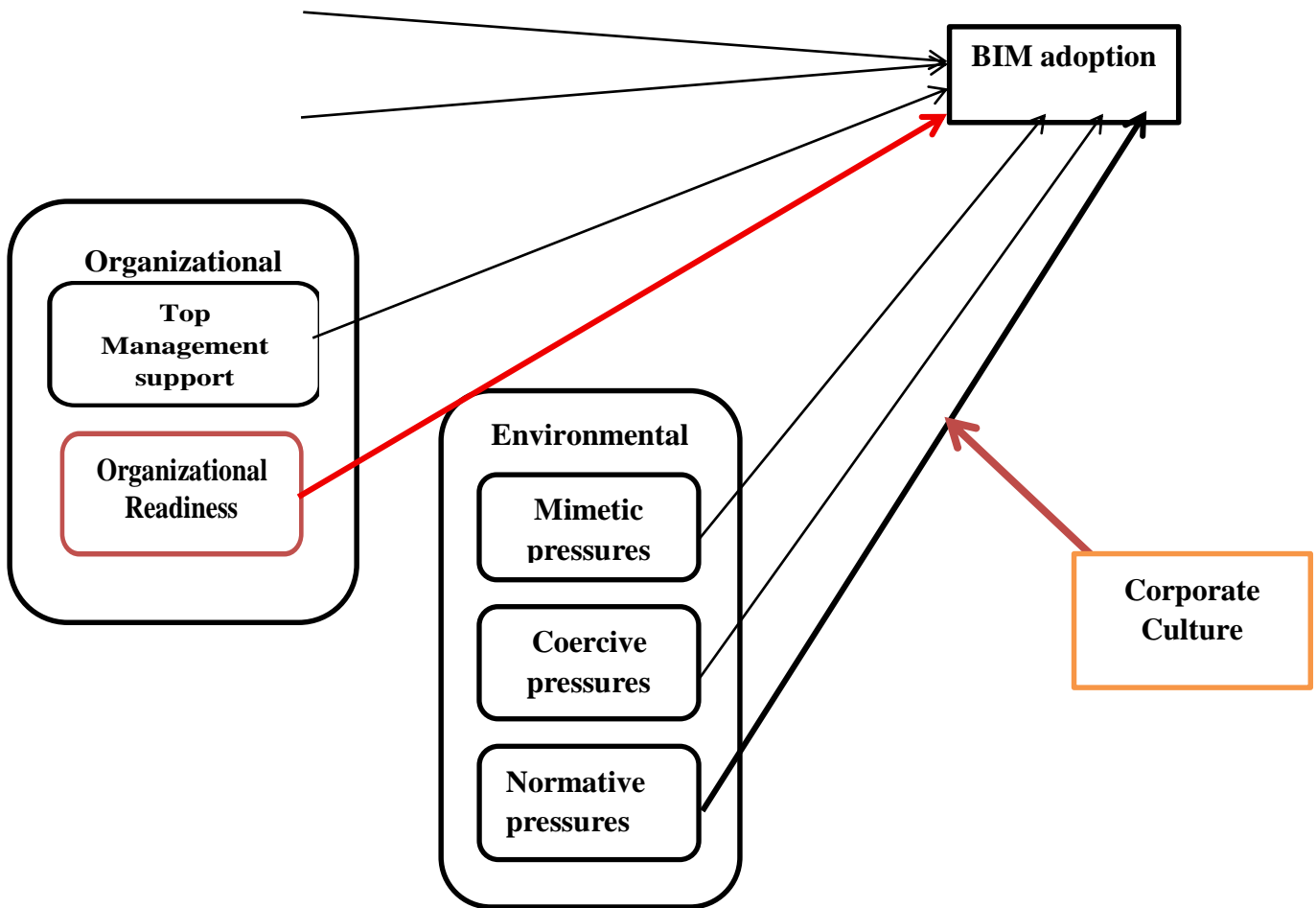


Figure 6. Conceptual framework of the study.

Within this framework, BIM adoption is treated as the dependent variable because the central purpose of the study is to explain why organizations in the Libyan construction sector decide to adopt or intensify the use of BIM as part of their organizational practices (Chowdhury et al., 2024). This treatment is theoretically appropriate because BIM is not simply a software choice, but a systemic innovation that requires organizations to adjust their processes, information practices, and collaborative arrangements in order to realize its benefits (Murguia et al., 2021). Recent literature also shows that BIM adoption must be understood as an organizationally embedded process that reflects the way firms interact with digital transformation over time rather than as a one-off technical decision (Chowdhury et al., 2024). Therefore, positioning BIM adoption as the dependent variable allows the study to examine how a set of internal and external factors collectively shape the organizational willingness and capacity to move toward BIM-based practice (Wang et al., 2025).

The technological dimension of the framework includes complexity, relative advantages, and compatibility because these variables represent the most theoretically stable

attributes through which organizations evaluate the practical desirability and feasibility of an innovation (Wang et al., 2025). Complexity is included because organizations are less likely to adopt BIM when it is perceived as difficult to understand, difficult to integrate, or difficult to sustain within existing operational routines (Chowdhury et al., 2024). Relative advantages are included because firms are more likely to adopt BIM when they believe that it offers superior performance, coordination, and project-management value compared with traditional practices (Wang et al., 2025). Compatibility is included because the organizational fit of BIM with existing systems, workflows, and technical arrangements affects whether adoption is perceived as manageable and worthwhile (Shirowzhan et al., 2020). Taken together, these three technological variables reflect the core evaluative logic through which firms judge whether BIM is an innovation that can and should be incorporated into organizational practice (Wang et al., 2025).

The organizational dimension of the framework includes top management support and organizational readiness because BIM adoption depends not only on the characteristics of the technology, but also on the internal capacity of the organization to authorize, support, and operationalize change (Tavallaei et al., 2022). Top management support is included because leadership commitment helps legitimize BIM internally, mobilize resources, and align the organization around a digital transformation agenda (Tavallaei et al., 2022). Recent BIM research also shows that senior management support contributes to BIM effectiveness by promoting learning, coordination, and collaborative culture inside project organizations (Villena-Manzanares et al., 2021). Organizational readiness is included because firms cannot adopt BIM effectively unless they possess sufficient internal preparedness in terms of awareness, skills, structure, process, and technological capability (Wang et al., 2025). Thus, the organizational dimension of the framework captures the extent to which the firm is internally able and willing to translate BIM from an external innovation into an organizationally embedded practice (Chowdhury et al., 2024).

The environmental dimension of the framework includes mimetic pressures, coercive pressures, and normative pressures because organizations adopt technologies not only in response to internal evaluation, but also in response to institutional forces operating in their external environment (DiMaggio & Powell, 1983). Mimetic pressure is included because construction organizations often respond to uncertainty by imitating peer firms or leading organizations that are perceived as successful adopters of BIM (Tavallaei et al., 2022). Coercive pressure is included because organizations may adopt BIM in response to the

expectations or requirements of governments, clients, major contractors, and other powerful stakeholders who can shape access to projects and legitimacy in the market (Tavallaei et al., 2022). Normative pressure is included because professional communities, educational institutions, consultants, and industry discourse increasingly frame BIM as an appropriate and expected form of modern construction practice (Tavallaei et al., 2022). The inclusion of these three pressures is conceptually important because it recognizes that BIM adoption occurs within an institutional field where legitimacy, compliance, imitation, and professional expectation all help shape organizational behavior (DiMaggio & Powell, 1983). (ResearchGate)

The inclusion of normative pressure is particularly important in this study because the literature suggests that it plays a prominent role in shaping organizational BIM adoption across AEC contexts (Tavallaei et al., 2022). Normative pressure is especially relevant to BIM because many organizations interpret BIM not only as a technical tool, but also as a signal of professionalism, modernity, and alignment with industry best practice (Chowdhury et al., 2024). This makes normative pressure analytically distinct from coercive and mimetic pressures because it is more directly associated with professional legitimacy and socially shared expectations within the field (DiMaggio & Powell, 1983). For that reason, normative pressure occupies a central place in the present conceptual framework and provides the focal pathway through which the study's moderating variable is introduced (Tavallaei et al., 2022).

Corporate culture is incorporated in the framework as a moderating variable because organizational culture shapes how external expectations are interpreted, accepted, resisted, or translated into internal action (Bogale & Debela, 2024). Contemporary culture research shows that culture comprises the shared values, assumptions, and norms that influence whether organizations are open to innovation, learning, collaboration, and strategic adaptation (Bogale & Debela, 2024). In the BIM context, this is especially important because BIM adoption requires organizations to accept new forms of coordination, knowledge exchange, and digital working practice, and such changes are more likely to occur in firms whose cultures support learning and transformation (Chowdhury et al., 2024). Recent synthesis evidence also indicates that organizational culture is a meaningful organizational factor in BIM adoption models, even though its role may differ depending on the way it is conceptualized (Wang et al., 2025). Therefore, the present study treats corporate culture as an internal conditioning factor that alters the organizational relationship between a specific environmental pressure rather than as a broad and undifferentiated association with the entire model (Bogale & Debela, 2024).

More specifically, corporate culture is proposed to moderate only the relationship between normative pressures and BIM adoption because this is the relationship in which culture is theoretically most relevant (DiMaggio & Powell, 1983). Normative pressure operates through values, legitimacy, and shared understandings of what is professionally appropriate, and these are precisely the domains through which culture exerts its strongest organizational influence (Bogale & Debela, 2024). When a firm has a culture that supports learning, collaboration, openness, and innovation, normative signals from the external professional environment are more likely to be interpreted as legitimate and worthy of implementation (Chowdhury et al., 2024). By contrast, when the prevailing culture is rigid, highly resistant to change, or weakly supportive of knowledge exchange, the same normative pressures may have a weaker effect on actual BIM adoption (Bogale & Debela, 2024). This moderation structure is also theoretically preferable because it avoids treating culture as a generalized explanatory factor and instead links it to the institutional pathway where its interpretive role is most conceptually defensible (Wang et al., 2025). (ResearchGate)

Based on this logic, the framework proposes eight direct relationships with BIM adoption and one moderating relationship (Wang et al., 2025). The direct relationships run from complexity, relative advantages, compatibility, top management support, organizational readiness, mimetic pressures, coercive pressures, and normative pressures to BIM adoption (Tavallaei et al., 2022). The moderating relationship proposes that corporate culture strengthens the positive relationship between normative pressures on BIM adoption when the internal cultural environment is supportive of innovation and organizational change (Bogale & Debela, 2024). In conceptual terms, the framework therefore combines a TOE-based structure with an institutional and cultural refinement that reflects the specific contribution of the present study (Chowdhury et al., 2024). This contribution lies in recognizing that external professional expectations do not produce identical organizational responses across all firms, because those expectations are filtered through internal cultural conditions before they are translated into adoption behavior (Bogale & Debela, 2024).

The framework is particularly suitable for the Libyan construction sector because BIM adoption in such a context is unlikely to be explained adequately by technological considerations alone (Chowdhury et al., 2024). Firms operating in developing or transitional environments often face uneven digital maturity, uncertain implementation pathways, and strong dependence on external professional and institutional cues, which makes the joint consideration of technological, organizational, and environmental factors especially necessary

(Wang et al., 2025). Under these conditions, BIM adoption is best understood as the outcome of a combined process in which organizations assess the characteristics of the technology, evaluate their internal readiness, respond to field-level pressures, and interpret these pressures through the lens of their internal culture (Bogale & Debela, 2024). Accordingly, the conceptual framework developed in this study provides a coherent and theoretically grounded basis for the subsequent development of hypotheses and for the empirical testing presented in the following chapters (Tavallaei et al., 2022).

2.10.2. Direct Effect Hypotheses

2.10.2.1. Complexity and BIM Adoption

Complexity is one of the most influential technological attributes in innovation adoption because organizations evaluate a new technology not only by its expected benefits, but also by the degree of difficulty associated with understanding, implementing, coordinating, and sustaining it in practice (Faiz et al., 2024). In the context of Building Information Modeling, complexity is particularly salient because BIM is not adopted as a simple software tool, but as a multidimensional sociotechnical innovation that affects information structures, work routines, coordination processes, and interorganizational interaction across the project lifecycle (Chowdhury et al., 2024). Contemporary BIM scholarship therefore treats complexity as an organizationally embedded condition rather than as a narrow technical inconvenience, since firms must assess whether they possess the procedural stability, digital capability, and managerial control needed to accommodate BIM-related change (Liao et al., 2022; Hochscheid & Halin, 2020).

At the conceptual level, complexity refers to the degree to which an innovation is perceived as difficult to comprehend, use, and integrate into established organizational practices (Faiz et al., 2024). In BIM settings, this definition must be expanded beyond software usability because BIM-related complexity includes model generation, coordination, interoperability management, standardization demands, staff training, process redesign, and the redistribution of roles and responsibilities within and across project teams (Ullah et al., 2022). This means that firms do not encounter BIM as an isolated digital package, but as a set of technological and organizational demands that must be understood and managed concurrently (Chowdhury et al., 2024).

However, in the present study, TCO is not treated as complexity in the sense of a purely inhibiting barrier. Rather, TCO refers to the perceived manageability of BIM-related complexity within the organization. On this basis, the theoretical expectation of the study is

not that greater burden promotes adoption, but that stronger perceived manageability of BIM-related complexity is positively associated with BIM adoption. In other words, organizations are expected to move more strongly toward BIM adoption when BIM-related demands are perceived as understandable, coordinable, and manageable within their existing organizational environment. This interpretation is consistent with the current operationalization of TCO in the study and aligns the technological hypothesis with the broader organizational logic of BIM adoption in the Libyan construction sector. Therefore, the following hypothesis is proposed:

H1: Complexity has a positive relationship with BIM adoption in the Libyan construction sector.

2.10.2.2. Relative Advantages and BIM Adoption

Relative advantage is one of the most established predictors of innovation adoption because organizations are more likely to adopt a technology when they perceive that it offers meaningful improvements over existing practices in terms of performance, efficiency, coordination, or strategic value (Faiz et al., 2024). In the BIM context, relative advantage refers to the extent to which firms believe that BIM can produce better outcomes than conventional methods of design coordination, information exchange, project control, and lifecycle data management (Murguia et al., 2021). This construct is especially important in organizational adoption research because firms rarely invest in major digital transitions unless the innovation is perceived as capable of generating superior project and business outcomes relative to established routines (Chowdhury et al., 2024). For that reason, relative advantage is not a minor technological preference, but a core evaluative mechanism through which decision makers judge whether BIM is worth adopting, legitimizing, and resourcing at the organizational level (Wang et al., 2024; Murguia et al., 2023).

From a theoretical perspective, relative advantage captures the degree to which an innovation is seen as better than the alternative it replaces, and this assessment is central to innovation diffusion because adoption decisions are fundamentally comparative rather than absolute (Faiz et al., 2024). Construction firms do not adopt BIM simply because BIM exists or because it is technologically advanced, but because they believe it can improve how projects are visualized, coordinated, planned, delivered, and controlled when compared with traditional fragmented practices (Chowdhury et al., 2024). In this regard, BIM-related relative advantage includes both direct operational gains, such as improved information consistency and reduced coordination errors, and broader organizational gains, such as better decision support, greater process transparency, and stronger competitiveness in increasingly digitalized markets (Wang

et al., 2025). This is why benefit perception remains a critical mechanism in BIM adoption research, because firms need to see BIM as producing tangible or strategically meaningful superiority before they commit the time, money, and organizational effort required for implementation (Murguia et al., 2023). Thus, the logic of relative advantage is entirely consistent with a TOE-based model, since the technological domain influences adoption not only through technical properties, but through how those properties are interpreted as value-creating by the organization (Faiz et al., 2024).

The BIM literature increasingly supports the view that benefit-oriented perceptions are central to organizational uptake. Chowdhury et al. argued that BIM adoption should be analyzed holistically because organizations interact with BIM throughout a transformative process that spans pre-adoption, implementation, and post-adoption stages, and this means perceived value continues to matter across the entire adoption trajectory rather than only at the initial decision stage (Chowdhury et al., 2024). When firms perceive BIM as improving collaboration, increasing information visibility, strengthening change management, and enabling more integrated delivery practices, adoption becomes easier to justify both internally and strategically (Chowdhury et al., 2024). Murguia et al. likewise framed BIM adoption as a systemic and multilevel process, showing that adoption cannot be understood adequately without considering how perceived benefits circulate across users, firms, and project coalitions rather than remaining confined to individual attitudes alone (Murguia et al., 2021). This multilevel interpretation is important because it clarifies that relative advantage in BIM is not merely a personal preference for new software, but an organizational judgment that the innovation can improve the functioning of the wider project system (Murguia et al., 2021). Consequently, if firms perceive BIM as offering superior project and organizational outcomes, the probability of adoption should increase rather than decrease (Chowdhury et al., 2024).

Direct empirical evidence also reinforces this argument. In their longitudinal study of contractors in Peru, Murguia et al. reported that contractors adopted BIM when they believed that BIM could improve project performance, rather than simply individual-level performance, which is highly relevant to the present study because it confirms that organizational adoption is strongly linked to expected project-level benefits (Murguia et al., 2023). This finding is especially significant because it moves the discussion beyond abstract pro-technology attitudes and shows that firms adopt BIM when they see it as a practical contributor to project effectiveness and delivery outcomes (Murguia et al., 2023). The implication for the current study is clear. When BIM is perceived as generating real advantages in coordination,

performance, and project execution, firms are more likely to consider adoption as a rational and worthwhile organizational decision (Murguia et al., 2023). This interpretation is also consistent with broader evidence in digital innovation research, where technologies that are perceived as performance-enhancing tend to enjoy stronger adoption support because decision makers are able to link the innovation directly to operational or strategic improvement (Faiz et al., 2024). Therefore, relative advantage should be expected to exert a positive association with BIM adoption in the Libyan construction sector as well (Murguia et al., 2023).

Additional support comes from meta-analytic and acceptance-oriented studies of BIM. Wang et al., in a 2024 meta-analysis covering ten years of BIM adoption research, found that performance expectancy, perceived value, and related benefit-oriented beliefs remain among the most influential drivers of BIM acceptance and behavioral intention across empirical studies and contexts (Wang et al., 2024). Although performance expectancy is not identical to relative advantage in a strict terminological sense, both constructs are conceptually aligned in that they reflect the perception that adopting BIM will produce superior outcomes compared with current practice (Wang et al., 2024). This is methodologically useful for the present study because it indicates that across different theoretical models, BIM adoption is consistently strengthened when actors perceive meaningful improvement in work performance, efficiency, or value creation (Wang et al., 2024). Such convergence across studies increases confidence in the positive expected relationship proposed here, since the broader BIM literature repeatedly returns to the same core idea, namely that adoption becomes more likely when the innovation is seen as advantageous rather than burdensome or neutral (Chowdhury et al., 2024). In that sense, relative advantage remains one of the most theoretically and empirically defensible positive antecedents of BIM adoption (Wang et al., 2024).

The practical content of relative advantage in BIM adoption is also supported by evidence on realized project outcomes. Wang et al. showed that higher BIM usage levels in Taiwanese public construction projects were associated with improved project performance, thereby demonstrating that the advantages attributed to BIM are not merely speculative claims but can materialize in measurable project results when usage deepens (Wang et al., 2025). This is important because firms are more likely to adopt an innovation when the benefits associated with it are not only theoretically plausible but also empirically observable in comparable construction settings (Wang et al., 2025). Likewise, recent survey evidence from architectural firms in Nigeria reported that respondents most strongly recognized visualization, information sharing, and database management among the practical benefits of BIM, suggesting that

perceived advantage remains a live and salient adoption enabler in developing-country construction contexts (Omokhua et al., 2025). These findings matter for the current study because they indicate that relative advantage in BIM is grounded in concrete expectations about project and information-management improvement rather than in vague technological enthusiasm (Omokhua et al., 2025). Where such expectations are strong, firms are more likely to regard BIM as a worthwhile investment and a legitimate modernization strategy (Wang et al., 2025).

The positive role of relative advantage is particularly relevant in environments where firms must justify digital investment under uncertainty. In such settings, organizations are unlikely to commit resources to BIM unless they believe that the technology offers clear superiority over existing methods in terms of project efficiency, communication quality, decision support, or competitive positioning (Saka et al., 2020). Saka et al. emphasized that BIM adoption in developing-country SMEs must be understood through the lens of sustainability and practical drivers, and their findings point to the importance of BIM characteristics and organizationally meaningful benefits in shaping sustained uptake rather than symbolic or temporary experimentation (Saka et al., 2020). This is highly relevant for the Libyan construction sector, where organizations are likely to weigh expected returns and tangible improvements carefully before embracing a complex digital innovation (Saka et al., 2020). If BIM is perceived as clearly superior to traditional approaches, its adoption becomes easier to defend, prioritize, and institutionalize within the firm (Murguia et al., 2021). If, however, the perceived benefits remain weak or ambiguous, adoption is likely to stall because the organization will see little reason to accept the costs and effort associated with change (Chowdhury et al., 2024). Thus, the expected direction of the relationship remains positive, because stronger perceived relative advantages should increase BIM adoption rather than hinder it (Saka et al., 2020).

It is also important to note that relative advantage at the organizational level does not mean short-term cost reduction only. In BIM adoption research, advantage can include superior coordination, better visualization for decision making, improved design-quality control, improved constructability management, stronger lifecycle information management, and enhanced capacity to participate in modernized procurement and project environments (Chowdhury et al., 2024). This broader understanding is essential because construction firms may adopt BIM not only to improve current projects, but also to strengthen future competitiveness, reputational positioning, and organizational learning capability (Murguia et

al., 2021). For that reason, relative advantage should be interpreted in this study as a multidimensional performance perception that links BIM to both operational and strategic superiority (Faiz et al., 2024). Once firms believe that BIM offers meaningful advantage over legacy methods, the innovation becomes easier to justify across managerial, technical, and project-delivery levels (Murguia et al., 2023). Accordingly, the literature provides strong theoretical and empirical grounds for expecting that relative advantage will positively influence BIM adoption in the Libyan construction sector (Wang et al., 2024; Chowdhury et al., 2024). Therefore, the following hypothesis is proposed:

H2: Relative Advantages have a positive and significant effect on BIM adoption.

2.10.2.3. Compatibility and BIM Adoption

Compatibility is a fundamental technological attribute in innovation adoption research because organizations are more likely to adopt an innovation when they perceive it as consistent with their existing values, work practices, technical systems, and operational needs (Shirowzhan et al., 2020). In the context of BIM, compatibility is especially important because firms rarely adopt BIM in a vacuum, and instead evaluate whether it can be aligned with established project routines, information management practices, contractual arrangements, and interorganizational workflows (Chowdhury et al., 2024). For this reason, compatibility should not be treated as a secondary issue in BIM studies, since it directly affects whether BIM is perceived as an achievable extension of current practice or as a disruptive intervention that requires excessive organizational adjustment (Murguia et al., 2021). This distinction is particularly important in organizational-level research because BIM adoption depends not only on the technical availability of tools, but also on the perceived fit between the innovation and the broader institutional and operational environment of the adopting firm (Shirowzhan et al., 2020). Accordingly, compatibility is expected to strengthen BIM adoption because organizations are more inclined to commit to innovations that can be integrated with manageable levels of change and organizational friction (El Masry & Chron  er, 2025).

At the conceptual level, compatibility refers to the degree to which an innovation is perceived as being consistent with existing work methods, organizational routines, prior experiences, and adopter needs (Shirowzhan et al., 2020). In BIM research, however, this concept requires careful clarification because the literature has often confused compatibility with interoperability, even though the two are not identical (Shirowzhan et al., 2020). Compatibility concerns the organizational and contextual fit of BIM with how firms operate, whereas interoperability concerns the technical ability of different digital systems to exchange

and use information effectively (Shirowzhan et al., 2020; Turk, 2020). This distinction is academically important because a firm may possess interoperable software tools while still facing weak compatibility if BIM does not align with internal workflows, role structures, delivery practices, or managerial expectations (Turk, 2020). Conversely, a firm may value BIM conceptually but still struggle to adopt it when software environments, information standards, or coordination practices do not support seamless integration with existing operations (Adetoro et al., 2025). Therefore, compatibility in the present study is understood as a broader organizational fit construct that includes, but is not limited to, technical interoperability (Shirowzhan et al., 2020).

The need to distinguish compatibility from interoperability is particularly important in the construction industry because BIM adoption takes place in a fragmented environment involving multiple disciplines, specialized software ecosystems, and distributed decision-making structures (Turk, 2020). Turk argued that interoperability challenges in construction cannot be reduced to a purely semantic or software-level problem because construction remains structurally fragmented and continues to depend on multiple specialized systems and actors rather than on one fully integrated digital environment (Turk, 2020). This argument has direct implications for BIM adoption because it shows that technical connection alone does not guarantee organizational usability or adoption feasibility (Turk, 2020). Shirowzhan et al. similarly concluded that compatibility is surprisingly underdeveloped and poorly understood in BIM literature, despite being one of the key concepts in diffusion-based innovation theory and one of the most relevant constructs for explaining organizational adoption behavior (Shirowzhan et al., 2020). Their analysis is especially useful for the present study because it shows that organizations must assess whether BIM fits with their specific context before adoption can progress in a meaningful way (Shirowzhan et al., 2020). As a result, compatibility becomes a positive driver of BIM adoption when firms perceive BIM as aligning with existing systems, routines, and needs, rather than conflicting with them (Murguia et al., 2021).

This positive role of compatibility is consistent with the broader organizational view of BIM adoption. Murguia et al. argued that BIM adoption should be interpreted systemically and at multiple levels because BIM-related change is distributed across individuals, firms, and project coalitions rather than being confined to isolated user decisions (Murguia et al., 2021). Under such conditions, compatibility matters because it affects whether BIM can be absorbed by the larger organizational and project system without triggering excessive misalignment or coordination burden (Murguia et al., 2021). If BIM is perceived as fitting existing processes,

project information flows, and collaborative relationships, organizations are more likely to regard adoption as feasible and worthwhile (Chowdhury et al., 2024). If, by contrast, BIM is perceived as demanding major changes to established routines, incompatible software arrangements, or unfamiliar data-management obligations, adoption is likely to weaken because the organization sees the implementation path as too disruptive (El Masry & Chron  er, 2025). This logic is especially important in construction because technology adoption often requires alignment not only within the firm, but also across the broader supply-chain and project-delivery network in which the firm operates (Murguia et al., 2021).

The empirical literature supports this reasoning. Shirowzhan et al. showed that compatibility should be treated as a measure of BIM adoption at the organizational level because it helps explain whether BIM applications are suited to firms with different stakeholder needs and different file-format practices (Shirowzhan et al., 2020). Their study found that the concept of compatibility had been overlooked or used incorrectly in prior BIM research, even though it is central to understanding the actual fit between BIM and the organizational environment in which implementation occurs (Shirowzhan et al., 2020). This finding is highly relevant because it indicates that BIM adoption is likely to accelerate when firms can judge BIM as contextually appropriate and practically alignable with their operations (Shirowzhan et al., 2020). Adetoro et al. provided related evidence from Malawi, where one of the highest-ranked technological factors influencing BIM implementation was the availability of BIM software that allows smooth integration with other software, along with clear protocols for data exchange and standardized data structures (Adetoro et al., 2025). These findings are useful for the current study because they indicate that organizations in developing-country contexts place high importance on compatibility-related issues when evaluating BIM implementation feasibility (Adetoro et al., 2025). In other words, when firms perceive better compatibility, BIM adoption becomes more realistic, less risky, and more operationally manageable (Adetoro et al., 2025).

Recent research on BIM obstacles in production-stage settings points in the same direction. El Masry and Chron  er reported that BIM adoption in construction production is hindered by technological and organizational barriers that reduce the practical usability of BIM in daily project execution, and their discussion explicitly relates these findings to diffusion-of-innovation variables such as complexity, compatibility, and perceived benefit (El Masry & Chron  er, 2025). This is important because it suggests that compatibility remains relevant not only in early adoption discourse, but also in real production environments where the success

of BIM depends on whether the technology can function coherently within operational systems and project practices (El Masry & Chron  er, 2025). When BIM tools, data requirements, and workflows do not fit with site-level operations, organizational responsibilities, and project control mechanisms, firms may treat BIM as cumbersome rather than enabling (El Masry & Chron  er, 2025). By contrast, when the technology can be integrated into ongoing work with reasonable continuity and without excessive disruption, adoption becomes easier to justify and sustain (El Masry & Chron  er, 2025). Thus, the empirical evidence supports the expectation that compatibility should positively influence BIM adoption rather than constrain it (El Masry & Chron  er, 2025).

The positive relationship between compatibility is also supported by contemporary reviews that treat BIM adoption as a holistic and context-dependent process. Chowdhury et al. emphasized that BIM adoption research has evolved from narrow, technology-centered perspectives toward a broader understanding that includes organizational structures, environmental conditions, and implementation realities (Chowdhury et al., 2024). Within this broader understanding, compatibility becomes a critical link between technological potential and organizational uptake because it determines whether BIM can be translated from abstract promise into workable organizational practice (Chowdhury et al., 2024). A technology may offer substantial theoretical benefits, but those benefits are unlikely to produce adoption if the technology does not align sufficiently with firm capabilities, routines, and project ecology (Murguia et al., 2021). This is one reason why compatibility has strong explanatory value in BIM studies, especially in late-adopting or resource-constrained markets, where even beneficial innovations may remain underused if they are perceived as poorly fitted to the existing environment (Adetoro et al., 2025). In this sense, compatibility can be understood as a practical gateway through which technological potential becomes organizationally actionable (Chowdhury et al., 2024).

From a strategic perspective, compatibility matters because adoption decisions in construction are rarely driven by technological merit alone. Firms must consider whether the innovation fits their procurement practices, project management systems, communication routines, workforce capabilities, and external collaboration requirements (Murguia et al., 2021). If the answer is affirmative, the organization is more likely to interpret BIM as a natural extension of its modernization efforts (Chowdhury et al., 2024). If the answer is negative, BIM may be viewed as requiring too much procedural adaptation, too much retraining, or too much digital restructuring to be implemented effectively (El Masry & Chron  er, 2025). This

reasoning is especially relevant for the Libyan construction sector because firms operating in transitional environments are likely to assess compatibility carefully before committing to complex digital change (Adetoro et al., 2025). Under such conditions, BIM adoption should become more likely when firms believe that BIM can coexist with their current systems, support their operational needs, and connect reasonably well with the actors and software environments involved in their projects (Shirowzhan et al., 2020). Thus, compatibility is expected to function as a positive adoption enabler rather than as a neutral background condition (Murguia et al., 2021).

It is also important to clarify that proposing a positive relationship between compatibility and BIM adoption does not imply that compatibility alone is sufficient for adoption. Rather, it means that higher perceived compatibility lowers the friction of adoption and increases the organization's willingness to proceed with implementation, all else being equal (Chowdhury et al., 2024). Organizations may still require leadership support, readiness, and external pressure, but the likelihood of adoption increases when the innovation is seen as fitting rather than conflicting with the organizational context (Faiz et al., 2024). This interpretation is theoretically stronger because it locates compatibility within a broader causal framework rather than treating it as a single decisive variable (Faiz et al., 2024). At the same time, the consistency of the available BIM literature indicates that compatibility deserves explicit inclusion in adoption models because it directly shapes whether BIM is seen as implementable in practical organizational terms (Shirowzhan et al., 2020). Therefore, based on the theoretical and empirical discussion above, the present study proposes that compatibility will positively and are significantly associated with BIM adoption in the Libyan construction sector (Adetoro et al., 2025). Accordingly, the following hypothesis is advanced:

H3: Compatibility has a positive and significant effect on BIM adoption (Shirowzhan et al., 2020).

2.10.2.4. Top Management Support and BIM Adoption

Top management support is a critical organizational predictor of innovation adoption because senior leaders define strategic priorities, authorize resource allocation, legitimize change initiatives, and shape the organizational climate within which new technologies are evaluated and implemented (Faiz et al., 2024). In BIM research, this construct is particularly important because BIM adoption usually requires more than technical acquisition, and instead depends on coordinated organizational change involving investment decisions, process

redesign, interdepartmental alignment, and sustained managerial oversight (Chowdhury et al., 2024). For this reason, BIM adoption at the firm level cannot be understood adequately without examining whether top management is willing to champion the transition, absorb the costs of change, and maintain commitment during the implementation process (Tavallaei et al., 2022). This point is especially relevant in construction organizations, where digital transformation often unfolds in fragmented and project-based environments that require visible leadership to overcome coordination barriers and institutional inertia (Villena-Manzanares et al., 2021). Accordingly, top management support is expected to have a positive effect on BIM adoption because firms are more likely to move toward adoption when senior leaders actively endorse and direct the implementation effort (El Masry et al., 2025).

At the conceptual level, top management support refers to the degree to which senior leaders provide commitment, attention, authority, and practical backing for the adoption of a new technology (Faiz et al., 2024). In the case of BIM, such support includes setting a strategic vision for digital transformation, approving investment in software and training, reducing uncertainty among employees, assigning responsibilities, and monitoring whether BIM implementation aligns with broader organizational objectives (Villena-Manzanares et al., 2021). This means that top management support should not be understood merely as passive approval, but as active managerial involvement in the transition from traditional project practices to digitally integrated workflows (Tavallaei et al., 2022). This construct matters because it links the organizational dimension of the TOE framework to the implementation capacity of the firm, thereby explaining why technically promising innovations are adopted more readily in organizations where leadership commitment is explicit and sustained (Chowdhury et al., 2024). When senior managers provide that commitment, BIM is more likely to be interpreted internally as a legitimate organizational priority rather than as an optional or peripheral technological experiment (Villena-Manzanares et al., 2021).

The BIM literature provides strong empirical support for this reasoning. Tavallaei et al. showed that top management support plays a central role in explaining organizational BIM adoption in the AEC industry, and their results indicated that its effect can be either direct or mediated depending on organizational business type (Tavallaei et al., 2022). More specifically, they found that in architecture and engineering organizations the influence of institutional pressures on organizational BIM adoption is mediated through top management support, whereas in contracting organizations normative pressure and top management support exert direct independent effects on the level of BIM adoption (Tavallaei et al., 2022). These findings

are highly relevant because they demonstrate that top management support is not simply an abstract organizational virtue, but an empirically observable mechanism through which broader environmental signals are translated into actual adoption behavior (Tavallaei et al., 2022). In other words, external pressure alone may not be sufficient to stimulate BIM adoption unless it is internalized and operationalized through managerial commitment at the highest organizational level (Tavallaei et al., 2022). This reinforces the present study's expectation that firms with stronger top management support will be more likely to adopt BIM than firms whose senior leadership remains indifferent or hesitant (Tavallaei et al., 2022). (Macquarie University)

A related body of evidence comes from studies of BIM effectiveness and organizational capability. Villena-Manzanares et al. found that senior management support exerts direct effects on BIM effectiveness and also improves BIM-related outcomes indirectly through technological learning and collaborative culture (Villena-Manzanares et al., 2021). Their findings are important because they show that management support is not valuable only at the initial adoption decision, but continues to matter during the development of internal technological capabilities and collaborative routines that make BIM function effectively in practice (Villena-Manzanares et al., 2021). They further argued that senior management support must establish leadership throughout the BIM implementation process in order to coordinate project-team activities, define responsibilities, and avoid misunderstandings during technologically intensive work processes (Villena-Manzanares et al., 2021). This interpretation is highly relevant to the present study because BIM adoption in the Libyan construction sector is unlikely to succeed through software acquisition alone, and will instead require organizational direction, capability development, and managerial reinforcement over time (Chowdhury et al., 2024). Therefore, top management support should be regarded as a substantive enabler of BIM adoption rather than as a symbolic contextual factor (Villena-Manzanares et al., 2021).

The positive role of top management support is also consistent with the broader shift in BIM scholarship from narrow technical explanations toward more holistic organizational interpretations. Chowdhury et al. emphasized that BIM adoption must be analyzed through the interaction of organizations and BIM across a transformative process, and they specifically identified organizational environment, power dynamics, and social structure as factors that had previously been overlooked in more technology-centered accounts (Chowdhury et al., 2024). This broader framing strengthens the argument for including top management support as a

direct predictor because leadership sits precisely at the intersection of organizational structure, strategic authority, and implementation power (Chowdhury et al., 2024). When leadership is weak, firms may experience uncertainty regarding implementation goals, inconsistent communication, and fragmented commitment across departments, all of which can undermine adoption (Faiz et al., 2024). By contrast, when top management support is strong, BIM adoption is more likely to be framed as a deliberate organizational transformation supported by direction, legitimacy, and accountability (Tavallaei et al., 2022). In this sense, top management support serves as a bridging mechanism between technological intention and organizational execution (Villena-Manzanares et al., 2021).

Recent evidence on BIM implementation barriers also supports the relevance of this variable. El Masry et al. showed that organizational barriers such as management support, internal workflows, and the availability of skilled personnel continue to limit contractors' capacity to implement BIM in construction production (El Masry et al., 2025). This is a significant finding because it suggests that managerial commitment remains important even after initial awareness of BIM has been established, especially in operational settings where the technology must be integrated into daily work practices and project execution routines (El Masry et al., 2025). Their study also concluded that, although contractors may possess some degree of internal technical readiness, scaling BIM implementation in practice still depends heavily on broader support structures, including organizational and systemic support conditions (El Masry et al., 2025). This supports the present study's argument that BIM adoption is unlikely to advance meaningfully in the absence of active top management support, since implementation demands leadership not only in planning and investment, but also in follow-through and organizational alignment (El Masry et al., 2025). Thus, managerial support should be expected to strengthen BIM adoption rather than remain neutral in its effect (El Masry et al., 2025).

From a strategic viewpoint, top management support matters because BIM adoption typically competes with other organizational priorities for scarce resources, managerial attention, and implementation capacity (Faiz et al., 2024). In firms where senior leaders perceive BIM as strategically relevant, they are more likely to authorize training, acquire software, invest in digital workflows, and encourage project teams to shift from traditional practices toward integrated information management (Villena-Manzanares et al., 2021). In firms where such support is absent, BIM may remain at the level of isolated experimentation or rhetorical interest because lower-level employees and technical specialists often lack the

authority to institutionalize major digital change on their own (Tavallaei et al., 2022). This is particularly important in construction settings, where the success of digital innovation often depends on clear decisions regarding standards, responsibilities, and interorganizational cooperation, all of which require top-level leadership endorsement (Chowdhury et al., 2024). Therefore, top management support should be understood not only as a motivational variable, but as an organizational mechanism that converts strategic intention into implementable adoption behavior (Faiz et al., 2024).

The relevance of this variable becomes even stronger in late-adopting and transitional environments. In such settings, BIM adoption often unfolds under conditions of regulatory ambiguity, uneven digital maturity, and uncertain market incentives, which means that firms need stronger internal leadership to justify and coordinate adoption decisions (Tavallaei et al., 2022). Under these conditions, top management support can reduce hesitation by signaling that BIM is a legitimate long-term direction, not a passing technical preference (Villena-Manzanares et al., 2021). It can also help align employees, reduce internal resistance, and stabilize implementation expectations across the organization, which are all necessary conditions for the successful adoption of complex digital technologies (El Masry et al., 2025). This interpretation is highly relevant to the Libyan construction sector, where firms are likely to face both internal and external uncertainties during any transition toward BIM-based practice (Chowdhury et al., 2024). Consequently, organizations with stronger top management support should be better positioned to adopt BIM than organizations whose leadership remains passive, fragmented, or unconvinced (Faiz et al., 2024).

It is important to clarify that top management support does not guarantee BIM adoption by itself. Rather, it increases the likelihood of adoption by improving organizational commitment, clarifying direction, and enabling the firm to mobilize the resources and routines needed for implementation (Tavallaei et al., 2022). This interpretation is theoretically stronger because it avoids treating leadership as an isolated predictor and instead places it within the broader organizational logic of the TOE framework (Faiz et al., 2024). Nevertheless, the available evidence consistently indicates that firms are more likely to adopt BIM when their senior leaders visibly support the transition, create enabling conditions for implementation, and sustain managerial attention during the adoption process (Villena-Manzanares et al., 2021). On this basis, the present study expects a positive and significant relationship between top management support and BIM adoption in the Libyan construction sector. Therefore, the following hypothesis is proposed:

H4: Top Management Support has a positive and significant effect on BIM adoption

2.10.2.5. Organizational Readiness and BIM Adoption

Organizational readiness is a pivotal explanatory construct in technology adoption research because organizations rarely implement complex digital innovations successfully unless they possess the internal conditions needed to absorb, coordinate, and sustain change (Faiz et al., 2024). In the BIM context, readiness is particularly important because BIM adoption requires firms to move beyond software acquisition toward structured changes in knowledge, processes, governance, and collaboration practices (Chowdhury et al., 2024). This means that BIM adoption depends not only on whether organizations are interested in digital innovation, but also on whether they are sufficiently prepared to convert that interest into operational capability (Magalhães et al., 2023). For that reason, organizational readiness is best understood as a foundational organizational condition that shapes whether BIM can be implemented in a realistic, coherent, and sustainable manner within the firm (Phung & Tong, 2021).

At the conceptual level, organizational readiness for BIM refers to the pre-implementation condition that reflects an organization's propensity to adopt BIM tools, workflows, and protocols as part of its operational system (Magalhães et al., 2023). This definition is analytically important because it positions readiness before implementation rather than after it, thereby distinguishing organizational preparedness from actual BIM use or post-adoption maturity (Magalhães et al., 2023). In other words, readiness concerns whether the organization has the awareness, competence, structure, and internal alignment necessary to begin BIM implementation meaningfully rather than symbolically (Ndwandwe et al., 2024). This study is distinction, because many firms may express interest in BIM while lacking the organizational conditions required for implementation, and such firms should not be treated as equally prepared adopters (Adam et al., 2022).

Recent BIM scholarship strongly supports the inclusion of organizational readiness as a direct predictor of adoption. Chowdhury et al. argued that BIM adoption research has moved from narrow, technology-centered explanations toward a more holistic understanding that incorporates organizational structures, implementation environments, and capability-related conditions (Chowdhury et al., 2024). Within that broader view, readiness becomes a central explanatory factor because organizations must develop the internal capacity to align technology, people, and processes before BIM can be institutionalized (Chowdhury et al.,

2024). This is fully consistent with the organizational dimension of the TOE framework, where adoption is influenced by the firm's internal ability to support, manage, and routinize innovation rather than by technological characteristics alone (Faiz et al., 2024). Accordingly, organizational readiness should be expected to increase BIM adoption because organizations that are more prepared internally are more capable of translating intent into practice (Faiz et al., 2024).

The structure of readiness itself has been clarified in recent BIM studies. Phung and Tong developed an organizational readiness framework for BIM implementation in large design companies and identified six major elements, namely strategy, organizational structure, process, people, technology, and information management (Phung & Tong, 2021). Their framework is especially valuable because it shows that BIM readiness is not reducible to software procurement or isolated technical skill, but instead requires coordinated preparation across managerial, structural, procedural, and informational dimensions (Phung & Tong, 2021). This interpretation strengthens the argument that readiness should influence adoption directly, because firms are more likely to adopt BIM when they possess the strategic orientation, organizational design, procedural discipline, human capability, technical infrastructure, and information routines needed for implementation (Phung & Tong, 2021). Put differently, BIM becomes more adoptable when the organization is organized to receive it, rather than merely exposed to it (Rajabi et al., 2022).

A similar conclusion emerges from the literature on organizational BIM capabilities. Rajabi et al. argued that many BIM benefits remain unrealized because organizations lack the capabilities needed to implement BIM effectively, and they therefore investigated the underlying factors that shape organizational BIM capabilities in Iran (Rajabi et al., 2022). Their study is highly relevant to the present study because it suggests that capability-related readiness is not a peripheral issue, but a decisive condition for whether BIM can move from aspiration to implementation (Rajabi et al., 2022). They showed that organizations must deliberately build their internal BIM capabilities if they are to realize the promised benefits of BIM, which implies that firms with stronger readiness conditions should be more likely to adopt BIM than firms whose internal capabilities remain weak or fragmented (Rajabi et al., 2022). In this sense, readiness operates as a capacity-based enabler of adoption, because it lowers the gap between perceived opportunity and organizational feasibility (Magalhães et al., 2023).

Empirical evidence from developing-country contexts reinforces this interpretation. Ndwandwe et al. examined organizational readiness for BIM implementation in Malawi and found that readiness can be meaningfully assessed through BIM awareness and competence among construction organizations (Ndwandwe et al., 2024). Their findings revealed a moderate level of BIM awareness and the presence of BIM-capable software, but also showed low levels of employee BIM competency and the limited use of BIM functionality beyond basic applications, indicating that readiness can remain incomplete even when initial technological exposure exists (Ndwandwe et al., 2024). This is an important insight because it shows that adoption depends not only on access to tools, but also on the organization's deeper preparedness to use BIM effectively (Ndwandwe et al., 2024). Therefore, organizational readiness should be viewed as a multidimensional condition that includes technical availability, human competence, and implementation preparedness rather than any single isolated indicator (Phung & Tong, 2021).

Evidence from other developing construction environments points in the same direction. Adam et al., in their study of BIM readiness in the Seychelles construction industry, found moderate awareness but low engagement in BIM education and training among construction professionals, which suggests that awareness alone is insufficient to establish readiness for broad BIM implementation (Adam et al., 2022). Their findings are important because they illustrate that readiness is weakened when organizations or industries do not sufficiently develop competence through formal learning and training processes (Adam et al., 2022). In adoption terms, this implies that firms may recognize BIM conceptually yet remain unable to adopt it effectively if they have not built the skills and organizational confidence needed for implementation (Adam et al., 2022). This also supports the broader argument that readiness should positively influence BIM adoption because the more prepared the organization is in terms of awareness, skills, and internal alignment, the more likely it is to move beyond interest toward actual implementation (Ndwandwe et al., 2024).

The conceptual work of Magalhães et al. further strengthens this argument by explicitly linking BIM readiness to the point immediately preceding adoption. Their model treats readiness as the situation before BIM implementation that represents the organization's propensity to adopt BIM workflows, tools, and protocols, and it frames readiness as a distinct and necessary stage in the broader BIM implementation pathway (Magalhães et al., 2023). This is particularly useful for the current study because it provides a rigorous conceptual justification for modeling readiness as an antecedent of BIM adoption rather than as an outcome or post-

hoc characteristic (Magalhães et al., 2023). If readiness is understood as the end condition of the preparation stage, then stronger readiness logically increases the likelihood that the organization will cross into actual adoption (Magalhães et al., 2023). Accordingly, the positive relationship proposed here is not only empirically plausible, but also conceptually consistent with the sequence of organizational change embedded in BIM implementation (Phung & Tong, 2021).

From an organizational change perspective, readiness matters because BIM implementation alters how organizations coordinate, communicate, and manage information. Firms that are unprepared for such changes are more likely to encounter internal resistance, procedural confusion, underutilization of software capability, and weak institutionalization after adoption begins (Chowdhury et al., 2024). By contrast, firms with stronger readiness are better able to align strategy, people, technology, and information processes, which makes BIM adoption more feasible and more likely to produce sustained organizational use (Rajabi et al., 2022). This distinction is particularly relevant in construction because BIM adoption is rarely a purely technical installation, and instead requires organizational reconfiguration at multiple levels (Phung & Tong, 2021). Therefore, readiness should be expected to function as a positive antecedent of BIM adoption because it reduces the implementation gap between technological ambition and organizational execution (Faiz et al., 2024).

The strategic importance of organizational readiness becomes even greater in late-adopting or transitional environments. In such settings, firms often face limited digital standardization, weak institutional support, capability shortages, and uncertainty regarding implementation pathways, all of which increase the importance of internal preparedness (Ndwandwe et al., 2024). For organizations in these environments, readiness helps determine whether BIM is interpreted as an achievable transformation or as an excessively risky undertaking (Adam et al., 2022). This observation is highly relevant to the Libyan construction sector, where firms are likely to evaluate BIM not only in terms of its benefits, but also in terms of whether they possess the internal knowledge, structure, and resources needed to implement it effectively (Magalhães et al., 2023). Under such conditions, higher organizational readiness should increase the probability of BIM adoption because it strengthens the organization's capacity to manage change, absorb complexity, and operationalize digital transformation (Rajabi et al., 2022).

It is important to clarify that organizational readiness does not guarantee successful BIM adoption on its own. Rather, it increases the likelihood of adoption by creating the internal conditions under which implementation becomes plausible, coordinated, and sustainable (Phung & Tong, 2021). This interpretation is theoretically stronger because it positions readiness within the broader causal structure of the TOE framework rather than treating it as a stand-alone predictor (Faiz et al., 2024). Nevertheless, the cumulative evidence reviewed above consistently indicates that organizations with higher levels of readiness in terms of awareness, competence, structure, process, and capability are more likely to adopt BIM than organizations that remain underprepared (Ndwandwe et al., 2024). On this basis, the present study expects a positive and significant relationship between organizational readiness and BIM adoption in the Libyan construction sector. Therefore, the following hypothesis is proposed:

H5: Organizational Readiness has a positive and significant effect on BIM adoption

2.10.2.6. Mimetic Pressures and BIM Adoption

Mimetic pressure occupies a central place in institutional explanations of innovation adoption because organizations often respond to uncertainty by imitating the practices of other organizations that are perceived as successful, legitimate, or strategically better positioned within the same field (DiMaggio & Powell, 1983; Ukobitz & Faullant, 2022). In the case of BIM, this logic is especially relevant because construction firms operate in highly visible project environments where digital practices, coordination methods, and competitive positioning can be observed across rival firms, clients, consultants, and supply-chain partners (Tavallaei et al., 2022; Chowdhury et al., 2024). As a result, firms may adopt BIM not only because of its intrinsic technical merits, but also because other influential or reputable organizations have already done so, thereby transforming BIM into a marker of modern practice and organizational legitimacy (Cao et al., 2014; Gao et al., 2023). This makes mimetic pressure a theoretically appropriate environmental predictor of BIM adoption within the TOE framework, because the external environment shapes adoption not only through formal regulation, but also through competitive imitation and field-level normalization of practice (Wang et al., 2025; Tavallaei et al., 2022). Accordingly, mimetic pressure is expected to exert a positive association with BIM adoption in the Libyan construction sector, where firms are likely to monitor and respond to what peer organizations and leading market actors are doing (Salem et al., 2025; Saka et al., 2024).

At the conceptual level, mimetic pressure refers to the tendency of organizations to model themselves on other organizations when they face uncertainty, ambiguity, or legitimacy concerns regarding appropriate courses of action (DiMaggio & Powell, 1983; Ukobitz & Faullant, 2022). In BIM adoption research, this means that firms may look outward to competitors, leading contractors, consultants, or internationally visible organizations when deciding whether BIM should be adopted as part of their own operational system (Cao et al., 2014; Tavallaei et al., 2022). This outward orientation is particularly strong in construction because organizations often make technology decisions under conditions of incomplete information, fragmented project governance, and evolving digital expectations, all of which encourage imitation of apparently successful adopters (Saka et al., 2024; Wang et al., 2025). Therefore, mimetic pressure should not be interpreted as a superficial social tendency, but as an institutional mechanism through which organizations reduce uncertainty and seek strategic legitimacy by aligning themselves with the visible practices of their peers and leaders (Ukobitz & Faullant, 2022; Gao et al., 2023). In the BIM context, this mechanism becomes stronger when firms perceive that leading organizations are gaining reputational, operational, or market advantages by using BIM, since imitation under those conditions becomes a rational organizational response rather than mere conformity (Cao et al., 2014; Salem et al., 2025).

The BIM literature provides substantial empirical support for the role of mimetic pressure in shaping adoption behavior. Cao et al., in one of the earliest institutional studies on BIM adoption, examined construction projects in China and found that mimetic pressure had a significant positive effect on BIM adoption activities, indicating that organizations were influenced by the visible practices of other organizations in their field (Cao et al., 2014). This finding remains important because it showed that institutional isomorphism could explain BIM adoption beyond purely technological or economic arguments, and that imitation was already functioning as an active driver of BIM diffusion in project-based settings (Cao et al., 2014). Although that study focused on the project level, its implications extend to organizational-level adoption because project decisions are often embedded in wider firm-level strategic responses to industry trends and competitive benchmarking (Chowdhury et al., 2024; Wang et al., 2025). Thus, the evidence from Cao et al. supports the proposition that firms are more likely to adopt BIM when they observe that comparable or leading organizations have already done so and have thereby set a field-level expectation of appropriate practice (Cao et al., 2014; Saka et al., 2024).

More recent organizational-level studies reinforce this same conclusion. Tavallaei et al. found that mimetic pressure significantly associated with the organizational level of BIM adoption in architecture, engineering, and construction organizations, thereby confirming that competitive and field-level imitation remains a relevant explanation for why firms decide to adopt BIM (Tavallaei et al., 2022). Their study is especially important for the present study because it examined organizational BIM adoption rather than only project-level application, which makes its findings directly relevant to firm-level adoption models such as the one proposed in this research (Tavallaei et al., 2022). Tavallaei et al. also showed that institutional pressures do not operate uniformly across all organizational types, but mimetic pressure remained among the significant external drivers of BIM adoption, which suggests that imitation is a robust mechanism even when other institutional forces vary by business type or organizational role (Tavallaei et al., 2022). This strengthens the present argument that firms in the Libyan construction sector are likely to be influenced by the observable BIM practices of peer organizations, especially where digital trajectories are still forming and firms search for cues about appropriate technological direction (Tavallaei et al., 2022; Chowdhury et al., 2024).

Further evidence is available from SME-focused BIM research in developing-country settings. Saka et al. examined institutional isomorphism and BIM adoption among Nigerian construction SMEs and found that mimetic pressure significantly associated with BIM adoption, while also contributing to BIM awareness in the SME segment of the industry (Saka et al., 2024). This finding is especially relevant because SMEs and late-adopting construction environments often resemble the kinds of resource-constrained and uncertainty-laden conditions under which mimetic processes become especially influential (Saka et al., 2024; Ukobitz & Faillant, 2022). In such settings, organizations frequently look to visible market actors and peer firms to reduce ambiguity regarding technology choice, implementation timing, and expected outcomes, which makes mimetic pressure a practical and not merely symbolic force in shaping adoption behavior (Saka et al., 2024; DiMaggio & Powell, 1983). The Nigerian evidence therefore supports the view that BIM adoption in the Libyan construction sector may likewise be encouraged when firms observe other organizations in the field embracing BIM and signaling that it has become part of accepted professional and competitive practice (Saka et al., 2024; Wang et al., 2025).

Recent evidence from the MENA region provides even more direct regional support for this expectation. Salem et al. investigated subcontractors' BIM deployment in large-scale construction projects in the MENA region and found that institutional pressures, including

mimetic pressure, significantly associated with BIM adoption, visualization, and productivity outcomes (Salem et al., 2025). This result is highly valuable for the current study because it comes from a regional context that is more proximate to Libya in institutional and construction-market terms than many Western or East Asian studies (Salem et al., 2025). The study indicates that subcontractors and related construction actors in the MENA region do not adopt BIM in isolation, but are affected by what other firms in their environment are doing and by the competitive pressures created when BIM becomes more visible in large-scale projects (Salem et al., 2025). This means that mimetic pressure is not merely a theoretical construct imported from institutional theory, but an empirically demonstrated driver of BIM-related organizational behavior in a region relevant to the present research context (Salem et al., 2025). Therefore, the MENA evidence strengthens the case for expecting a positive relationship between mimetic pressure and BIM adoption in Libya as well (Salem et al., 2025).

The positive role of mimetic pressure is also supported by recent synthesis work. Wang et al., in their 2025 TOE-based meta-analysis of BIM adoption, concluded that among external environmental factors, mimetic pressure stood out as a primary driver in promoting BIM adoption, which is a highly important finding for the present study because it aggregates evidence across multiple empirical studies and contexts (Wang et al., 2025). The value of this result lies in the fact that it moves beyond isolated case findings and suggests that imitation-based environmental influence is consistently associated with BIM adoption across the extant literature (Wang et al., 2025). In methodological terms, a meta-analytic result of this kind gives stronger support to hypothesis development because it indicates that the mimetic effect is not accidental or contextually trivial, but recurrent enough to emerge across a broad empirical base (Wang et al., 2025). Consequently, the present study has strong grounds for proposing that mimetic pressure should increase, rather than decrease or leave unchanged, the likelihood of BIM adoption at the organizational level (Wang et al., 2025; Chowdhury et al., 2024).

An additional mechanism through which mimetic pressure may shape BIM adoption can be understood through identity and perceived usefulness. Gao et al. found that institutional pressures positively affected BIM identity formation in the construction industry and that perceived usefulness mediated this relationship, thereby suggesting that external institutional forces help organizations make sense of BIM as a meaningful and legitimate part of who they are becoming as modern construction actors (Gao et al., 2023). Although their study treated institutional pressures more broadly rather than isolating mimetic pressure alone, it is highly relevant because it clarifies how external pressures can affect internal interpretations of BIM

and not only behavioral outcomes (Gao et al., 2023). In practical terms, when firms repeatedly observe peer organizations and industry leaders using BIM, they may begin to see BIM not only as technically useful, but also as part of the identity of a competent and contemporary construction firm, which can intensify the adoption impulse created by mimetic pressure (Gao et al., 2023; Tavallaei et al., 2022). This interpretive mechanism is important because it shows that mimetic pressure may work through both competitive imitation and cognitive normalization of BIM as standard practice (Gao et al., 2023).

From a broader institutional perspective, mimetic pressure matters because organizations under uncertainty often prefer to imitate known models rather than experiment with unproven internal pathways (DiMaggio & Powell, 1983; Ukobitz & Faullant, 2022). Ukobitz and Faullant, in their study of radical technology adoption in the context of 3D printing, found that mimetic pressures exerted the highest impact among the institutional forces examined, and they argued that organizations use imitation to reduce uncertainty while responding to perceived technological value in their environment (Ukobitz & Faullant, 2022). Although this study is not BIM-specific, it is theoretically useful because it confirms that mimetic pressure can be a powerful driver of organizational technology adoption beyond the BIM literature alone (Ukobitz & Faullant, 2022). This matters for the current study because BIM, like other transformative technologies, often requires firms to make adoption decisions under uncertainty regarding benefits, implementation pathways, and strategic timing, and under such conditions imitation becomes more likely as a rational organizational strategy (Ukobitz & Faullant, 2022; Saka et al., 2024). Therefore, the positive role proposed here is consistent both with BIM-specific evidence and with wider institutional research on innovation adoption (Ukobitz & Faullant, 2022).

In the Libyan construction sector, this logic is expected to be particularly relevant because firms are likely to operate in a field where digital transformation remains uneven, information is imperfect, and organizations look outward for signals about appropriate modernization pathways (Chowdhury et al., 2024). Under such circumstances, if competitors, large contractors, consultants, or regionally visible firms are seen adopting BIM, other firms may interpret that behavior as evidence that BIM adoption is becoming necessary for maintaining competitiveness and professional legitimacy (Salem et al., 2025; Saka et al., 2024). This means that mimetic pressure may help push BIM from being perceived as an optional innovation to being perceived as an expected industry practice, which in turn should increase adoption propensity (Tavallaei et al., 2022; Gao et al., 2023). It is important to note, however,

that mimetic pressure does not act in isolation and does not guarantee adoption on its own, but rather increases the likelihood of adoption by making imitation of successful or visible peers appear strategically sensible under uncertainty (Wang et al., 2025; Ukobitz & Faullant, 2022). On this basis, and in light of the theoretical and empirical evidence reviewed above, the present study proposes the following hypothesis:

H6: Mimetic Pressures have a positive and significant effect on BIM adoption.

2.10.2.7. Coercive Pressures and BIM Adoption

Coercive pressure is a key institutional mechanism in organizational adoption research because firms often respond to formal or quasi-formal demands imposed by actors that possess regulatory authority, contractual power, or market dominance (DiMaggio & Powell, 1983; Tavallaei et al., 2022). In the context of BIM, coercive pressure refers to the extent to which organizations feel compelled to adopt BIM because of requirements originating from governments, major clients, public procurement systems, project owners, consultants, or other powerful stakeholders in the construction environment (Cao et al., 2014; Salem et al., 2025). This construct is especially important in construction because digital practices are frequently shaped not only by internal choice, but also by obligations embedded in tendering conditions, contractual arrangements, public-sector mandates, and client expectations regarding project delivery and information management (Tavallaei et al., 2022; Salem et al., 2025). For that reason, coercive pressure is conceptually distinct from both mimetic and normative pressure, since it operates through dependency and obligation rather than through imitation or professional socialization alone (DiMaggio & Powell, 1983; Wang et al., 2025). Accordingly, coercive pressure is expected to exert a positive association with BIM adoption because organizations are more likely to adopt BIM when important external actors make its use necessary, advantageous, or difficult to avoid (Cao et al., 2014; Tavallaei et al., 2022).

At the theoretical level, coercive pressure emerges when organizations conform to rules, expectations, or directives established by more powerful institutions or stakeholders upon whom they depend for legitimacy, access, resources, or contracts (DiMaggio & Powell, 1983). In BIM-related settings, this means that firms may move toward adoption because BIM becomes linked to compliance, market access, or client satisfaction rather than because the organization independently initiates the transition on purely internal grounds (Tavallaei et al., 2022). This is highly relevant in the construction industry because firms frequently operate in networks structured by strong asymmetries of influence, especially between contractors and

public agencies, subcontractors and main contractors, or service providers and large clients (Salem et al., 2025). As a result, the decision to adopt BIM may become partly coercive when refusal or delay would threaten organizational legitimacy, competitive eligibility, or contractual participation in major projects (Cao et al., 2014; Saka et al., 2024). From a TOE perspective, this makes coercive pressure a valid environmental predictor because it captures how the external institutional setting can shape organizational adoption decisions beyond internal preferences and technical evaluations alone (Wang et al., 2025; Tavallaei et al., 2022).

The BIM literature provides direct empirical support for this relationship. Cao et al. examined isomorphic pressures and BIM adoption in construction projects and found that coercive pressure had a significant positive effect on BIM adoption activities, indicating that formal external demands can stimulate organizations to adopt BIM even when other institutional influences vary in strength (Cao et al., 2014). This study remains highly relevant because it was among the first to demonstrate, within a BIM-specific setting, that external pressure from powerful stakeholders is not merely a contextual background condition, but an active driver of BIM-related behavior (Cao et al., 2014). The importance of this finding lies in the fact that BIM adoption often involves investments and organizational adjustments that firms may hesitate to undertake voluntarily, yet become more willing to accept when these adjustments are linked to mandatory or high-stakes project conditions (Cao et al., 2014). Therefore, the evidence from Cao et al. supports the proposition that coercive pressure increases BIM adoption by changing the cost-benefit structure of non-adoption, thereby making resistance more difficult to sustain (Cao et al., 2014).

More recent organizational-level evidence reinforces this conclusion. Tavallaei et al. found that coercive pressure significantly associated with top management support for BIM adoption in AEC organizations, and they argued that this type of pressure commonly arises from the requirements of government agencies, clients, and other external actors with the power to shape organizational priorities (Tavallaei et al., 2022). Their study is especially important because it shows that coercive pressure affects BIM adoption not only directly through external obligation, but also indirectly by motivating senior managers to support the technology internally when the environment makes BIM adoption strategically or institutionally necessary (Tavallaei et al., 2022). This is a crucial insight for the current study because it indicates that coercive pressure is capable of penetrating the organization's internal decision structure rather than remaining an external signal with no operational effect (Tavallaei et al., 2022). In practical terms, when major clients, regulators, or procurement systems demand BIM-related capability,

organizational leaders are more likely to legitimize BIM adoption, allocate resources, and encourage implementation across the firm (Tavallaei et al., 2022). This mechanism strongly supports the expectation that coercive pressure should positively influence BIM adoption in organizational settings (Tavallaei et al., 2022).

Evidence from recent SME research also points in the same direction. Saka et al. reported that coercive pressure significantly associated with BIM adoption among construction SMEs in Nigeria, showing that formal and quasi-formal external demands can matter even in smaller firms operating under constrained capability conditions (Saka et al., 2024). This finding is particularly useful because SMEs often face stronger dependence on clients, contractors, and market gatekeepers than larger organizations do, which means coercive mechanisms may be especially salient in shaping their adoption behavior (Saka et al., 2024). The Nigerian evidence therefore suggests that coercive pressure can operate effectively in developing-country construction environments where firms may not initially adopt BIM out of internal strategic initiative, but later do so because powerful external actors make adoption increasingly difficult to avoid (Saka et al., 2024). This logic is highly relevant to the present study because firms in late-adopting or transitional environments often rely heavily on external cues, contracts, and institutional expectations when evaluating whether a major digital transition should proceed (Wang et al., 2025). Accordingly, coercive pressure should be expected to increase BIM adoption rather than inhibit it (Saka et al., 2024; Tavallaei et al., 2022).

Regional evidence from the MENA construction industry provides even more direct support. Salem et al. examined subcontractors' BIM deployment in large-scale construction projects in the MENA region and found that coercive pressure significantly associated with BIM adoption and related deployment outcomes, alongside mimetic and normative pressure (Salem et al., 2025). This result is especially important for the present study because it comes from a regional environment more comparable to Libya than many studies conducted in advanced economies (Salem et al., 2025). The relevance of Salem et al. lies in the fact that subcontractors and other project actors in the MENA region often operate under strong dependency relationships, where demands from major contractors, project owners, and high-value projects can decisively shape technology adoption behavior (Salem et al., 2025). Under such conditions, BIM adoption may become partly a response to external requirements associated with market participation, project eligibility, and expected performance standards rather than purely voluntary internal modernization (Salem et al., 2025). This strengthens the argument that coercive pressure should positively affect BIM adoption in the present study's

model, particularly because the mechanism has already been demonstrated in a regionally relevant construction context (Salem et al., 2025).

The broader evidence synthesis also supports the positive role of coercive pressure, though with an important nuance. Wang et al., in their recent TOE-based meta-analysis of BIM adoption factors, concluded that environmental pressures do promote BIM adoption, while also noting that mimetic pressure appears more effective overall than coercive pressure in the aggregated evidence base (Wang et al., 2025). This nuance is valuable because it allows the present study to formulate a theoretically balanced argument. Coercive pressure does not need to be the strongest environmental predictor in order to remain a significant positive predictor of BIM adoption (Wang et al., 2025). What matters is that the weight of evidence indicates that external mandates, client requirements, and institutional dependencies increase the probability of adoption relative to situations where such pressures are absent (Wang et al., 2025; Cao et al., 2014). Thus, the meta-analytic evidence does not weaken the present hypothesis. Instead, it refines it by showing that coercive pressure is a meaningful positive driver, even if other institutional pressures may sometimes be stronger under certain conditions (Wang et al., 2025).

From an organizational decision-making perspective, the relationship between coercive pressure can be explained by the way it alters the consequences of non-adoption. When BIM is demanded by public authorities, incorporated into client specifications, or associated with access to strategic projects, the organization no longer compares adoption only against internal convenience or short-term cost concerns (Tavallaei et al., 2022). Instead, it must also consider the risks of non-compliance, exclusion from tenders, weakened client relationships, or reduced legitimacy in the marketplace (Salem et al., 2025). In this sense, coercive pressure increases BIM adoption not necessarily by making BIM easier, but by making non-adoption less viable or less attractive in institutional and commercial terms (Cao et al., 2014). This mechanism is analytically important because it explains why organizations may adopt BIM even when internal readiness is incomplete, provided that the external compulsion is sufficiently strong (Tavallaei et al., 2022). Therefore, coercive pressure can be understood as a force that shifts adoption from a discretionary strategic option toward a more necessary organizational response (Saka et al., 2024).

This reasoning is especially relevant in contexts where digital transformation is uneven and where firms may otherwise postpone BIM adoption until uncertainty declines. In such settings, coercive pressure may serve as an external accelerator by creating decision urgency

and by signaling that BIM is becoming institutionally embedded in how construction work is specified and delivered (Wang et al., 2025). For firms in the Libyan construction sector, this means that BIM adoption is likely to become more probable when project owners, procurement bodies, large contractors, or regulators require BIM-related capability as a condition of participation or performance. Even where organizations remain uncertain about the full benefits of BIM, coercive pressure can still increase adoption by raising the institutional and commercial costs of delaying action (Tavallaei et al., 2022; Salem et al., 2025). On this basis, and in light of the theoretical and empirical evidence reviewed above, the present study proposes the following hypothesis:

H7: Coercive Pressures have a positive and significant effect on BIM adoption.

2.10.2.8. Normative Pressures and BIM Adoption

Normative pressure is a major institutional mechanism in organizational adoption research because it arises from professional norms, industry expectations, educational influences, and shared beliefs about what constitutes appropriate organizational behavior within a given field (DiMaggio & Powell, 1983). In the context of BIM, normative pressure refers to the extent to which organizations feel encouraged to adopt BIM because professional communities, consultants, industry associations, expert networks, and prevailing sectoral expectations increasingly frame BIM as a legitimate and desirable practice in construction management and project delivery (Tavallaei et al., 2022). This type of pressure is especially important in construction because many technology decisions are shaped not only by formal regulation or direct competition, but also by evolving professional standards regarding what modern, competent, and credible firms are expected to do (Chowdhury et al., 2024). For that reason, normative pressure is theoretically distinct from coercive pressure and mimetic pressure, since it operates through legitimacy, professionalization, and socially shared expectations rather than through mandatory compliance or simple imitation alone (DiMaggio & Powell, 1983). Accordingly, normative pressure is expected to have a positive association with BIM adoption because organizations are more likely to adopt BIM when it becomes associated with accepted professional practice and with the institutional image of what a capable construction firm should be (Tavallaei et al., 2022).

At the conceptual level, normative pressure reflects the influence of professional communities and socialized expectations that define the “right” or “proper” way of acting within an organizational field (DiMaggio & Powell, 1983). In BIM-related settings, this means

that firms may adopt BIM because architects, engineers, project managers, consultants, and industry networks increasingly regard BIM as an expected component of contemporary construction practice rather than as an optional or experimental technology (Tavallaei et al., 2022). This matters because organizations often seek legitimacy not only through compliance with formal rules, but also through conformity with the informal standards and values that dominate their professional environment (Gao et al., 2023). When BIM is repeatedly framed in professional discourse as a marker of competence, modernization, and sectoral progress, firms are more likely to see adoption as institutionally appropriate and strategically prudent (Salem et al., 2025). Thus, normative pressure should be understood as an environmental force that shapes organizational behavior by making BIM adoption appear professionally expected and socially validated within the construction field (Saka et al., 2024).

The BIM literature offers direct and strong support for this interpretation. Tavallaei et al. reported that normative pressure was the prominent institutional pressure affecting the level of BIM adoption across all types of AEC organizations included in their study, which makes this source especially important for the present research because it provides direct BIM-specific evidence at the organizational level (Tavallaei et al., 2022). Their findings also indicated that normative pressure had the most important role in motivating top managers to extend the use of technology in their organizations, which suggests that normative influence can operate not only as a background condition, but also as a concrete driver of managerial action in favor of BIM adoption (Tavallaei et al., 2022). This is a crucial point because it shows that normative pressure is not merely symbolic, and instead can shape both organizational intention and internal strategic support for BIM implementation (Tavallaei et al., 2022). In analytical terms, the findings of Tavallaei et al. justify treating normative pressure as a direct environmental antecedent of BIM adoption in the present model rather than as a peripheral contextual factor (Tavallaei et al., 2022).

The significance of normative pressure is also supported by recent evidence from developing-country SME environments. Saka et al. found that coercive and mimetic pressures significantly associated with BIM adoption in Nigerian construction SMEs, while normative pressure had the strongest association with BIM awareness in SMEs, which is particularly relevant because awareness is often a precursor to more extensive organizational uptake of innovation (Saka et al., 2024). This finding is important for the present study because SME-dominated and capability-constrained environments frequently resemble late-adopting construction contexts in which professional norms and industry discourse help shape how

organizations interpret emerging technologies (Saka et al., 2024). When BIM becomes increasingly visible in training, consultancy discourse, professional interaction, and industry conversation, normative pressure can elevate the salience and legitimacy of BIM even before the organization reaches full implementation readiness (Saka et al., 2024). Consequently, normative pressure contributes to BIM adoption by normalizing the technology within the professional field and by strengthening the perception that serious organizations ought to be moving in that direction (DiMaggio & Powell, 1983).

Further support comes from the MENA-region evidence, which is particularly valuable for a study focused on the Libyan construction sector. Salem et al. found that normative pressure significantly associated with BIM-related awareness, adoption, training, visualization, and productivity among subcontractors in large-scale construction projects in the MENA region, thereby demonstrating that normative institutional forces have practical effects on BIM-related organizational outcomes in a regional context relevant to this study (Salem et al., 2025). This is an important result because it shows that normative pressure is not limited to abstract professional discourse, but can shape multiple dimensions of BIM deployment and utilization in real construction settings (Salem et al., 2025). The regional relevance of this evidence strengthens the present argument because Libya shares important institutional and market characteristics with the broader MENA construction environment, including uneven digital diffusion, project-based coordination, and sensitivity to external professional signals (Chowdhury et al., 2024). Therefore, the MENA findings increase confidence in expecting that normative pressure will positively influence BIM adoption in the Libyan construction sector as well (Salem et al., 2025).

The mechanism through which normative pressure affects BIM adoption can also be understood in cognitive and identity-related terms. Gao et al. showed that institutional pressures positively affected BIM identity formation in the construction industry, while perceived usefulness played a mediating role in that process, which indicates that external institutional influences can shape how organizations understand BIM as part of their own professional and organizational identity (Gao et al., 2023). Although their study addressed institutional pressures more broadly, it remains highly relevant because normative pressure is precisely the institutional mechanism most closely associated with professional expectations and legitimacy-building processes (Gao et al., 2023). This suggests that normative pressure may influence BIM adoption not only by making BIM appear common or expected, but also by making BIM appear congruent with the self-understanding of organizations that seek to

present themselves as advanced, competent, and professionally credible actors within the construction industry (Gao et al., 2023). In this sense, normative pressure can deepen BIM adoption by reshaping organizational interpretation, not merely by exerting external social force (Tavallaei et al., 2022).

Recent synthesis work supports the broader importance of environmental institutional forces in BIM adoption and helps contextualize the place of normative pressure within that category. Wang et al., in their TOE-based meta-analysis of BIM adoption, concluded that environmental factors do promote BIM adoption across the accumulated literature, even though the relative strength of specific institutional pressures may vary across contexts (Wang et al., 2025). This result matters because it confirms that institutional pressures are not secondary to technological and organizational factors, but instead form a meaningful part of the explanatory structure of BIM adoption models (Wang et al., 2025). Within that broader institutional environment, Tavallaei et al. provide particularly strong evidence that normative pressure can be the most prominent pressure relationships with BIM adoption in AEC organizations, which supports treating normative pressure as a distinct and theoretically meaningful predictor in this study (Tavallaei et al., 2022). Therefore, the present hypothesis is not based on isolated empirical observations, but on a pattern of findings showing that institutionalized expectations within the professional field can influence organizations' willingness to adopt BIM (Wang et al., 2025).

The role of normative pressure becomes even more compelling when BIM adoption is viewed as part of a wider process of sectoral modernization. Chowdhury et al. argued that BIM adoption research has moved from narrow and fragmented perspectives toward a more holistic understanding that recognizes the interaction of BIM with organizational environment, social structure, and culture across different stages of adoption (Chowdhury et al., 2024). This broader perspective is important because normative pressure operates precisely through these environmental and social channels, shaping how organizations interpret what is considered acceptable, progressive, and strategically legitimate behavior in the construction field (Chowdhury et al., 2024). As BIM becomes increasingly embedded in industry discourse, educational curricula, consultancy advice, and interorganizational interaction, the normative expectation to adopt it is likely to grow stronger even in the absence of strict mandates (Salem et al., 2025). Consequently, normative pressure can help move BIM adoption from the margins of organizational experimentation toward the center of accepted professional practice (Gao et al., 2023).

From an organizational decision-making perspective, normative pressure matters because firms do not operate as isolated technical entities. They operate within professional and institutional fields where external judgments about legitimacy, competence, and modernity affect how internal decisions are made (DiMaggio & Powell, 1983). In such environments, the adoption of BIM may be viewed as a signal that the organization is aligned with prevailing professional standards and with the direction of the industry as a whole (Tavallaei et al., 2022). This signaling function is especially relevant in construction because firms often compete not only on price and capacity, but also on perceived professionalism, innovation orientation, and capability to work according to contemporary industry practices (Salem et al., 2025). Therefore, normative pressure can positively influence BIM adoption by making the technology appear institutionally legitimate, professionally endorsed, and reputationally valuable (Gao et al., 2023).

This logic is highly relevant to the Libyan construction sector, where BIM adoption is still likely to be associated with both uncertainty and emerging institutional expectations. In such a setting, organizations may look to professional communities, consultants, regional market trends, and internationally recognized industry practices when judging whether BIM should be incorporated into their own organizational model (Chowdhury et al., 2024). If BIM is increasingly represented within those channels as a standard of contemporary professional conduct, normative pressure should strengthen the organization's inclination to adopt it (Saka et al., 2024). This is especially likely when managers perceive that refusing or delaying BIM adoption could make the organization appear outdated, disconnected from current professional practice, or less credible in the eyes of clients and partners (Gao et al., 2023). On this basis, normative pressure is expected to function as a positive environmental driver of BIM adoption rather than as a neutral background condition (Tavallaei et al., 2022).

It should be clarified that normative pressure does not guarantee BIM adoption by itself. Rather, it increases the likelihood of adoption by strengthening institutional legitimacy, shaping managerial interpretation, and making BIM appear professionally appropriate and socially expected within the construction field (DiMaggio & Powell, 1983). This interpretation is theoretically stronger because it avoids reducing adoption to a single cause and instead places normative pressure within the broader environmental structure of the TOE framework (Wang et al., 2025). Nevertheless, the available BIM-specific evidence consistently indicates that normative pressure is positively associated with BIM-related awareness, managerial support, identity formation, and organizational adoption (Tavallaei et al., 2022; Salem et al., 2025; Gao

et al., 2023). Accordingly, and in light of the theoretical and empirical arguments presented above, the present study proposes the following hypothesis:

H8: Normative Pressures have a positive and significant effect on BIM adoption.

2.10.3. Corporate Culture as a Moderator of the Relationship Between Normative Pressures and BIM Adoption

Corporate culture is introduced in this study as a moderating variable because organizational culture shapes how external expectations are interpreted, internalized, and translated into actual organizational behavior (Bogale & Debela, 2024). Corporate culture reflects the shared values, norms, assumptions, and behavioral patterns that guide how members of an organization think about change, legitimacy, collaboration, and innovation (Bogale & Debela, 2024). In technology adoption settings, culture matters because the same external signal may produce very different organizational responses depending on whether the internal cultural environment encourages openness, learning, adaptability, and experimentation or, alternatively, favors rigidity, caution, and routine preservation (Scaliza et al., 2022). This broader understanding is highly relevant to BIM adoption because BIM is not merely installed as software, but is enacted through new routines of collaboration, model-based communication, and digitally mediated decision-making that require cultural acceptance as well as technical implementation (Chowdhury et al., 2024). Recent BIM literature also confirms that BIM-related transformation is associated with organizational and social factors rather than by technological features alone, which means that cultural conditions must be treated as part of the explanatory structure of adoption rather than as background context only (Chowdhury et al., 2024).

The decision to model corporate culture as a moderator, rather than as a broad direct predictor across all relationships, is theoretically justified by the specific nature of normative pressure (DiMaggio & Powell, 1983). Normative pressure works through professional standards, shared expectations, educational influences, expert discourse, and collective understandings of what constitutes proper organizational conduct within a field (DiMaggio & Powell, 1983). In the BIM context, normative pressure arises when consultants, professional networks, industry bodies, training systems, and sectoral discourse increasingly frame BIM as a legitimate and expected way of working in contemporary construction (Tavallaei et al., 2022). Because these pressures operate through meaning, legitimacy, and social expectation, their effect depends heavily on how organizations interpret those signals internally (Gao et al., 2023). Corporate culture is therefore especially relevant to normative pressure because culture

determines whether external professional expectations are welcomed as legitimate guidance, filtered as irrelevant fashion, or resisted as misaligned with internal values and routines (Bogale & Debela, 2024). For this reason, culture is expected to alter the strength of the relationship between normative pressures and BIM adoption more directly than it would alter the relationship between purely technological attributes such as compatibility or complexity (Scaliza et al., 2022).

The institutional literature provides a strong conceptual basis for this argument. DiMaggio and Powell explained that organizations often conform to institutionalized expectations not only because of direct coercion or imitation, but also because professionalization and shared norms define what is regarded as legitimate organizational behavior within a field (DiMaggio & Powell, 1983). However, institutional pressures do not act mechanically, because organizations still interpret and enact them through their internal systems of values and assumptions (Bogale & Debela, 2024). This means that normative pressure may be present in the external environment, yet its behavioral effect on adoption can remain weak if the organization's culture does not support learning, collaboration, and receptiveness to professional change (Scaliza et al., 2022). Conversely, when an organization has a supportive culture, the same normative signal can become a strong adoption trigger because employees and managers are more willing to accept the external expectation as relevant, legitimate, and consistent with the organization's direction (Behl et al., 2022). In this sense, culture does not replace normative pressure, but conditions how strongly normative pressure can influence BIM adoption inside the organization (Behl et al., 2022).

BIM-specific studies support the importance of this conditioning logic. Tavallaei et al. found that normative pressure was the most prominent institutional pressure relationships with BIM adoption across AEC organizations and that it also played the most important role in motivating top managers to extend technology use within their firms (Tavallaei et al., 2022). This finding is highly important for the present study because it shows that normative pressure is not marginal in BIM adoption, but central to it (Tavallaei et al., 2022). At the same time, Tavallaei et al. do not argue that institutional pressure operates independently of internal organizational dynamics, and their results instead show that the internal organizational setting remains crucial in determining whether external pressures are transformed into managerial commitment and organizational action (Tavallaei et al., 2022). This insight directly supports the present moderator hypothesis, because if normative pressure already has a meaningful direct role, then the next theoretically relevant question is whether internal cultural conditions

strengthen or weaken that influence (Tavallaei et al., 2022). The present study answers that question by proposing that corporate culture is the internal condition that shapes how strongly normative pressure translates into BIM adoption (Bogale & Debela, 2024).

Additional BIM literature further reinforces this view by showing that culture is deeply implicated in BIM-enabled organizational change. Alankarage et al., in their systematic literature review, argued that BIM adoption and implementation are associated with organizational and professional culture change, and they proposed a framework for moving organizations from weak BIM culture to stronger and more mature BIM culture (Alankarage et al., 2023). This is a critical contribution because it suggests that culture is not external to BIM, but part of the organizational environment through which BIM-related change unfolds (Alankarage et al., 2023). In a related study, Alankarage et al. diagnosed organizational BIM culture using Schein's model and showed that BIM adoption and use are intertwined with cultural artifacts, espoused values, and underlying assumptions inside organizations (Alankarage et al., 2024). These findings matter directly for the current hypothesis because they indicate that culture affects whether BIM-related expectations can become embedded in organizational practice rather than remaining superficial or symbolic (Alankarage et al., 2024). Therefore, if normative pressure makes BIM appear professionally expected, corporate culture determines whether that expectation will be absorbed and enacted as part of organizational behavior (Alankarage et al., 2023).

The same pattern appears in studies that link culture to knowledge, collaboration, and BIM-related organizational functioning. Tennakoon et al. found that organizational culture strongly influences knowledge management in BIM-enabled construction environments, particularly through factors such as coordination and integration, empowerment, and organizational learning (Tennakoon et al., 2022). This is highly relevant because normative pressure can only drive adoption effectively if the organization has cultural mechanisms that allow knowledge about BIM to circulate, be discussed, and be turned into coordinated organizational response (Tennakoon et al., 2022). Villena-Manzanares et al. similarly showed that collaborative culture contributes to BIM effectiveness and that senior management support must promote collaborative culture and technological learning if BIM capabilities are to improve (Villena-Manzanares et al., 2021). These findings strengthen the moderator argument because they show that a supportive cultural environment is not just generally beneficial, but specifically important for making BIM-related change operationally viable (Villena-Manzanares et al., 2021). Thus, when normative pressure encourages organizations toward

BIM, a stronger corporate culture should amplify that effect by enabling learning, coordination, and internal acceptance of the pressure's implications (Tennakoon et al., 2022).

Broader innovation and digital adoption studies provide additional support for treating organizational culture as a moderator. Behl et al. showed that organizational culture played a critical moderating role in the adoption of artificial intelligence for disaster relief operations, demonstrating that culture can alter how technological and contextual drivers influence adoption behavior in complex organizational settings (Behl et al., 2022). Although that study was not BIM-specific, it is theoretically useful because it confirms that organizational culture can function contingently by strengthening or weakening the relationship between other explanatory variables on technology adoption (Behl et al., 2022). Scaliza et al. likewise found that adhocracy culture most strongly influenced the adoption of inbound and outbound open innovation flows, whereas hierarchy culture discouraged such adoption, which indicates that organizational culture shapes whether external ideas and innovation signals are embraced or suppressed (Scaliza et al., 2022). These findings align closely with the current study because normative pressure is itself an external signal arising from the professional environment, and culture should therefore affect whether that signal is translated into openness toward BIM or into organizational reluctance (Scaliza et al., 2022). In parallel, Dai et al. found that organizational culture moderated the relationship between market pressure and corporate environmental strategy, showing more generally that culture can alter how external pressures influence organizational response (Dai et al., 2018). This evidence from adjacent domains strengthens the plausibility of the proposed moderation structure in the present BIM study (Dai et al., 2018).

Regional and contextually proximate evidence also supports the proposed relationship. Salem et al. found that normative pressure significantly associated with BIM awareness, adoption, training, visualization, and productivity among subcontractors in large-scale construction projects in the MENA region (Salem et al., 2025). This finding is especially relevant because it comes from a regional context more comparable to Libya than many studies drawn from mature Western BIM markets (Salem et al., 2025). If normative pressure already exerts a positive direct influence in the MENA construction environment, then it is theoretically reasonable to expect that internal organizational culture will shape how strongly that regional normative environment is translated into firm-level BIM adoption (Salem et al., 2025). In firms where culture supports collaboration, learning, knowledge sharing, and openness to change, normative signals from the external environment are more likely to be accepted as appropriate

and acted upon (Tennakoon et al., 2022). In firms where culture is rigid, hierarchical, or resistant to new ways of working, the same normative signals may be acknowledged but not meaningfully enacted (Scaliza et al., 2022). Therefore, corporate culture should positively moderate the relationship between normative pressure and BIM adoption in the Libyan construction sector by intensifying the organizational relationship between external professional expectations (Salem et al., 2025).

This moderating logic also helps explain why the current study restricts the moderating role of corporate culture to the normative pressure pathway rather than extending it indiscriminately across all TOE relationships. Normative pressure is the institutional force most directly connected to meanings, values, legitimacy, and professional expectations, which are precisely the domains through which organizational culture operates most strongly (DiMaggio & Powell, 1983). By contrast, technological attributes such as complexity and compatibility are more directly concerned with the properties and fit of the technology itself, while coercive pressure operates more directly through obligation and dependency and mimetic pressure through imitation under uncertainty (Wang et al., 2025). Corporate culture may matter broadly across many organizational processes, but its strongest and most conceptually defensible contingent role in this model lies in shaping how the organization interprets and responds to externally generated professional norms regarding BIM (Bogale & Debelo, 2024). This theoretical specificity strengthens the contribution of the study because it avoids an overly diffuse moderation claim and instead focuses on the pathway where the moderator is most substantively meaningful (Behl et al., 2022). In other words, the model does not suggest that culture changes everything equally, but that culture changes most powerfully the organizational relationship between normative institutional expectations (Dai et al., 2018).

In the Libyan construction sector, this argument is especially compelling because firms are likely to face evolving but still uneven expectations regarding digital transformation, professional modernization, and BIM-based project delivery (Chowdhury et al., 2024). Under such conditions, normative pressure may already encourage firms to view BIM as an increasingly legitimate and desirable practice, yet whether that encouragement turns into actual adoption will depend in part on the organization's internal cultural orientation (Salem et al., 2025). A supportive corporate culture should make firms more willing to interpret external BIM expectations as aligned with their identity, learning orientation, and organizational future, thereby strengthening the positive relationship between normative pressure on BIM adoption (Alankarage et al., 2024). A weak or resistant culture, by contrast, should dampen that effect

by limiting knowledge sharing, reducing openness to change, and weakening the internal legitimacy of BIM-related transformation (Tennakoon et al., 2022). Under such conditions, normative pressure may already lead firms to view BIM as an increasingly legitimate and desirable practice, yet whether that tendency is translated into actual adoption is likely to depend in part on the organization's internal cultural orientation (Salem et al., 2025). A supportive corporate culture is therefore expected to strengthen the positive relationship between Normative Pressures and BIM adoption by making firms more willing to interpret external BIM expectations as aligned with their identity, learning orientation, and organizational future, whereas a weak or resistant culture is expected to weaken that relationship by limiting knowledge sharing, reducing openness to change, and weakening the internal legitimacy of BIM-related transformation (Alankarage et al., 2024; Tennakoon et al., 2022). On this basis, and in light of the theoretical and empirical evidence reviewed above, the present study proposes the following hypothesis:

H9: Corporate Culture positively moderates the relationship between Normative Pressures and BIM adoption.

2.11. Chapter Summary

This chapter established the conceptual, theoretical, contextual, and empirical foundation of the present study by reviewing the literature on Building Information Modeling adoption in a structured and cumulative manner. It clarified that BIM should be understood as a broader information-centered and lifecycle-oriented approach rather than a mere three-dimensional modeling tool. The chapter justified the study theoretically through the TOE framework, Institutional Theory, and the organizational culture literature, which together provide a coherent basis for explaining BIM adoption in organizational settings. The review further showed that BIM adoption is associated with technological, organizational, and environmental factors, while Corporate Culture was identified as a focused moderating variable in the relationship between Normative Pressures and BIM adoption only. Overall, the chapter identified the research gap and provided the basis for the study's conceptual framework and hypotheses.

3. CHAPTER THREE: METHODOLOGY

3.1. Introduction

This chapter presents the methodological framework adopted to examine the relationship between technological, organizational, and environmental factors and Building Information Modeling adoption in the Libyan construction sector, with Corporate Culture specified as a moderator of the relationship between Normative Pressures and BIM adoption only (Park et al., 2020; Hair et al., 2019). The chapter explains the research philosophy, research approach, research design, study context, target population, unit of analysis, sampling strategy, data collection procedure, measurement of variables, and data-analysis procedure used in the study (Ponto, 2015; Sekaran & Bougie, 2019). The methodological choices reported in this chapter were designed to ensure consistency between the conceptual model of the study, the nature of the empirical data, and the statistical techniques used to test the hypotheses of the study (Hair et al., 2019; Tavallaei et al., 2022).

3.2. Research Design

This study is grounded in the positivist research philosophy (Park et al., 2020). Positivism assumes that social and organizational phenomena can be investigated through observable indicators, structured measurement, and systematic empirical analysis (Park et al., 2020). It is particularly appropriate when the purpose of the research is to examine theoretically specified relationships among variables through transparent and replicable procedures rather than through interpretive exploration of subjective meanings (Park et al., 2020). In the present study, the principal constructs, namely Complexity, Relative Advantages, Compatibility, Top Management Support, Organizational Readiness, Mimetic Pressures, Coercive Pressures, Normative Pressures, Corporate Culture, and BIM adoption, are treated as latent constructs that can be operationalized through measurable indicators and analyzed statistically (Hair et al., 2019). This is consistent with the positivist view that valid knowledge can be developed by translating abstract concepts into observable measures and assessing theoretically informed expectations against empirical data (Park et al., 2020; Hair et al., 2019).

The adoption of positivism is further justified by the explanatory aim of the study. The present research does not seek to explore BIM adoption through interpretive interviews, phenomenological inquiry, or ethnographic immersion (Maier et al., 2023). Rather, it seeks to examine whether identifiable technological, organizational, and environmental factors are

statistically associated with BIM adoption in the Libyan construction sector, and whether Corporate Culture moderates the relationship between Normative Pressures and BIM adoption (Hair et al., 2019). Such a purpose is methodologically aligned with positivism because it requires formal hypothesis testing, structured operationalization, and systematic analysis of relationships among predefined constructs rather than open-ended textual interpretation (Park et al., 2020). Positivism is therefore adopted in this study not as a generic methodological label, but as the philosophical position most closely aligned with the objectives, model structure, and analytical logic of the research (Park et al., 2020).

Consistent with its positivist orientation, the study adopts a deductive research approach (Park et al., 2020). Deduction is appropriate when research begins with established theory and prior empirical evidence, derives hypotheses from that theoretical foundation, and then evaluates those hypotheses using empirical data (Park et al., 2020; Hair et al., 2019). This is the logic followed in the present study. The study did not begin from unstructured field observations intended to generate theory inductively (Ponto, 2015). Instead, it began from a theoretically anchored model grounded in the Technology, Organization, and Environment framework, Institutional Theory, and the literature on organizational culture and innovation adoption (Hair et al., 2019). The variables were specified in advance, the relationships among them were conceptually defined before data collection, and the empirical stage of the study was designed to assess whether the observed data support those predefined expectations (Hair et al., 2019). This sequence reflects a direct and methodologically defensible application of deductive logic (Park et al., 2020).

The deductive approach is especially suitable because the study is based on a closed and theoretically structured model rather than an exploratory list of loosely related factors (Hair et al., 2019). Each direct hypothesis links one explanatory construct to BIM adoption, while the moderating hypothesis specifies the interaction between Corporate Culture and Normative Pressures in relation to BIM adoption (Hair et al., 2019). Such a structure requires clear conceptual specification, prior definition of measurement items, and the use of an analytical procedure capable of assessing multiple direct and moderating relationships simultaneously (Hair et al., 2019). A deductive approach supports this process by moving in a disciplined sequence from theory to hypotheses, from hypotheses to operationalization, and from operationalization to empirical testing (Park et al., 2020; Hair et al., 2019).

In line with the positivist philosophy and deductive approach, the study adopts a quantitative research design (Ponto, 2015; Hair et al., 2019). A quantitative design is appropriate because the study seeks to measure latent constructs through structured indicators and to examine the relationships among those constructs using statistical procedures (Ponto, 2015; Hair et al., 2019). More specifically, the study employs a cross-sectional survey design, since the data were collected at a single point in time from a defined group of respondents in order to examine the relationships among the study variables within the Libyan construction sector (Ponto, 2015; Maier et al., 2023). This design is practical and methodologically suitable for organizational and management research in which the objective is to explain statistically significant associations among multiple constructs within a defined empirical setting (Maier et al., 2023).

The survey method is particularly suitable for the present study because it enables the collection of standardized responses from knowledgeable participants working in the Libyan construction sector, including architects, engineers, contractors, consultants, and project managers who are capable of evaluating BIM-related organizational conditions (Ponto, 2015). The selected design also aligns closely with the analytical technique adopted in the study, namely Partial Least Squares Structural Equation Modeling using SmartPLS, because the model includes multiple latent constructs, several direct paths, and one theoretically bounded moderating relationship (Hair et al., 2019). Accordingly, the research design provides a coherent methodological platform for examining BIM adoption in the Libyan construction sector and for assessing the focused moderating role of Corporate Culture in the relationship between Normative Pressures and BIM adoption (Tavallaei et al., 2022; Alankarage et al., 2023).

3.3. Study Context

3.3.1. The Libyan Construction Sector as the Context of the Study

The present study is situated in the Libyan construction sector because this sector provides a highly relevant empirical setting for examining the organizational adoption of Building Information Modeling under conditions of uneven digital maturity, institutional fragility, and constrained implementation capacity (Elghdhan et al., 2023; El Hajj et al., 2023; Solla et al., 2025). The choice of context is not incidental because the logic of the study requires a setting in which BIM is practically important, yet still insufficiently institutionalized as a

routine organizational practice (Elghdhan et al., 2023; Solla et al., 2025). Libya fits this requirement because BIM is relevant to the needs of the sector, while its adoption remains limited, uneven, and associated with interacting technological, organizational, and environmental constraints (Elghdhan et al., 2023; El Hajj et al., 2023).

The construction sector in Libya is important because it is directly tied to infrastructure provision, public and private project delivery, and wider economic activity, yet it continues to operate under conditions that complicate project coordination, resource management, and implementation efficiency (International Monetary Fund, 2024; Shebob et al., 2012). Research on Libya's construction industry has pointed to persistent delivery problems, including delays, coordination weaknesses, and managerial difficulties that reduce overall project performance (Shebob et al., 2012). These features are methodologically important because BIM is widely justified in the literature as a digital approach capable of improving information integration, coordination quality, communication, visualization, and decision support across the project life cycle (Succar, 2009; Chowdhury et al., 2024).

Libya-specific BIM evidence reinforces this contextual justification in a direct way (Elghdhan et al., 2023; Solla et al., 2025). Elghdhan et al. (2023) found that BIM adoption in Libyan construction firms is associated with technological, organizational, and environmental conditions rather than by purely technical considerations alone (Elghdhan et al., 2023). More recent evidence also indicates that conventional work methods remain dominant in practice and that BIM experience in many firms is still limited (Solla et al., 2025). These findings matter methodologically because they show that the phenomenon under investigation is real, current, and sufficiently visible to justify empirical analysis in the Libyan setting (Elghdhan et al., 2023; Solla et al., 2025).

3.3.2. Justification for Selecting the Libyan Construction Sector

The selection of the Libyan construction sector is justified on theoretical, empirical, and practical grounds (Elghdhan et al., 2023; Solla et al., 2025). Theoretically, the study requires a context in which the explanatory value of technological, organizational, and environmental variables can be meaningfully examined (Hair et al., 2019). If BIM were already fully normalized and deeply embedded in the sector, the study would be less able to observe the active influence of complexity, perceived advantage, compatibility, leadership support, readiness, and institutional pressures on organizational adoption decisions (Hair et al., 2019). Libya is therefore theoretically appropriate because BIM has clear practical relevance, but still

remains insufficiently institutionalized for the explanatory model to retain analytical power (Elghdhan et al., 2023; Solla et al., 2025).

The empirical justification is equally strong because Libya-specific BIM research remains limited in volume and fragmented in scope when compared with more mature national literatures (Elghdhan et al., 2023; El Hajj et al., 2023). The practical justification is also compelling because Libya continues to need stronger systems for planning, coordination, cost control, and implementation discipline in construction-related activity, while digital construction methods remain weakly embedded in daily organizational practice (International Monetary Fund, 2024; Solla et al., 2025). This context is especially suitable for examining the environmental and cultural dimensions of the model because mimetic, coercive, and normative pressures are likely to operate in an uneven and still-emerging institutional environment (DiMaggio & Powell, 1983; Tavallaei et al., 2022; Alankarage et al., 2023).

3.4. Population, Unit of Analysis, and Sampling

This section clarifies the target population, the level of analysis, the source of empirical observation, the sampling strategy, and the methodological basis on which sample adequacy was judged in the present study. These elements must be stated precisely because the conceptual model of the study examines Building Information Modeling adoption as an organizational phenomenon associated with technological, organizational, and environmental conditions, while the empirical evidence is collected through survey responses from professionals working in the Libyan construction sector (Ahmed & Kassem, 2018; Elghdhan et al., 2023). For this reason, the present study does not rely on a complete national census of all construction firms in Libya. Instead, it focuses on relevant and informed respondents who are professionally positioned to evaluate BIM-related organizational conditions, managerial support, readiness factors, and external sectoral pressures from within the construction field (Ponto, 2015; Palinkas et al., 2015). This methodological framing is more appropriate than attempting to define the study through exhaustive firm-level enumeration, particularly in a context where the research depends on informed professional judgment and purposive access to knowledgeable respondents rather than on a complete and fixed population register of firms (Palinkas et al., 2015; Elghdhan et al., 2023).

3.4.1. Target Population

The target population of the present study consists of professionals working in or closely with construction-related organizations in the Libyan construction sector who are

sufficiently knowledgeable to provide informed responses regarding BIM adoption and the technological, organizational, and environmental conditions associated with it (Elghdhan et al., 2023; Tavallaei et al., 2022). This population includes engineers, architects, project managers, contractors, subcontractors, consultants, and BIM-related specialists, because these groups are directly involved in planning, coordination, supervision, implementation-related processes, and organizational decision environments relevant to BIM in construction settings (Elghdhan et al., 2023; Tavallaei et al., 2022). Defining the population in this way is methodologically justified because the present study does not examine BIM as a narrow user-level software preference. Rather, it investigates BIM adoption as an organizational innovation outcome that must be understood through the perspectives of professionals capable of observing organizational routines, managerial support, readiness conditions, and external institutional pressures from informed positions within the sector (Ahmed & Kassem, 2018; Ponto, 2015). Accordingly, the target population is framed in terms of knowledgeable sector participants rather than a purely administrative listing of firms, which is more consistent with both the conceptual logic of the study and the practical realities of data collection in the Libyan construction context (Elghdhan et al., 2023; Ponto, 2015).

3.4.2. Unit of Analysis

The present study examines Building Information Modeling adoption at the organizational level, because the core constructs of the model, including BIM adoption, top management support, organizational readiness, and corporate culture, are conceptually situated within the organizational context rather than at the purely personal level (Ahmed & Kassem, 2018; Tavallaei et al., 2022). However, the empirical data were collected from knowledgeable professional respondents working in the Libyan construction sector, who served as informants capable of evaluating the organizational conditions relevant to BIM adoption within their professional settings (Ponto, 2015; Elghdhan et al., 2023). Accordingly, the organizational level constitutes the substantive level of analysis in the study, while professional respondents represent the source of observation and measurement. This distinction is methodologically important because it preserves the organizational logic of the conceptual model while remaining fully consistent with the survey-based data collection strategy used in the study (Ahmed & Kassem, 2018; Ponto, 2015). In this sense, the study does not interpret the responses as isolated private preferences, but as informed indicators of organizational conditions relevant to BIM adoption in the Libyan construction sector (Elghdhan et al., 2023; Tavallaei et al., 2022).

3.4.3. Sampling Technique

The present study employed purposive sampling because the research required respondents who were not merely available, but substantively relevant to the research problem and capable of providing informed answers concerning BIM adoption in construction organizations (Palinkas et al., 2015). Purposive sampling is particularly suitable when participation depends on the possession of knowledge, professional experience, or sectoral characteristics directly related to the phenomenon under investigation (Palinkas et al., 2015; Ponto, 2015). In the present study, this requirement was especially important because BIM adoption in Libya remains uneven, and not every person working in or around the construction sector would be equally capable of assessing the technological, organizational, and environmental conditions examined in the model (Elghdhan et al., 2023; Solla et al., 2025). The use of purposive sampling therefore strengthens the methodological fit between the study objectives and the achieved dataset by prioritizing informed relevance over broad but potentially weakly informed participation (Palinkas et al., 2015; Ponto, 2015). In practical terms, the study deliberately sought respondents whose roles, sectoral engagement, and professional positioning made them suitable sources of evidence on organizational BIM uptake and the associated conditions affecting it in the Libyan construction environment (Elghdhan et al., 2023; Tavallaei et al., 2022).

3.4.4. Sample Size Determination

Sample-size determination in the present study was addressed at the methodological planning stage rather than by reference to the final achieved number of usable responses. This distinction is important because sample-size determination is an *ex ante* theoretical and methodological justification, whereas the final retained sample is an *ex post* empirical outcome that can only be reported after data collection, screening, and preparation for analysis are completed (Ponto, 2015). In the present study, sample adequacy was judged in relation to the analytical requirements of the proposed research model rather than by reference to a complete national population frame of construction firms in Libya. This approach is methodologically appropriate because the study employed purposive sampling and relied on knowledgeable professional respondents rather than attempting a census of all firms in the sector (Palinkas et al., 2015; Ponto, 2015). In PLS-SEM research, sample adequacy is evaluated primarily in light of model complexity, the number of latent constructs, the number of structural paths to be estimated, and the need to obtain stable and interpretable estimates for both the measurement model and the structural model (Hair et al., 2019). Since the present model includes multiple

latent constructs, eight direct paths to BIM adoption, and one focused moderating effect involving Corporate Culture and Normative Pressures, the study required a sample that would be methodologically sufficient for reliable model estimation and hypothesis testing under PLS-SEM procedures (Hair et al., 2019). Accordingly, sample adequacy was justified on analytical and methodological grounds at the planning stage, while the achieved usable sample is reported later in the study under the respondent-profile section after the completion of data collection and screening procedures (Ponto, 2015; Hair et al., 2019). This separation enhances methodological clarity because it prevents confusion between intended sampling logic and achieved empirical sample realization (Ponto, 2015; Hair et al., 2019).

3.5.Data Collection Method and Procedure

The present study relied on primary data collected through a structured questionnaire administered to professionals working in the Libyan construction sector. The use of primary survey data was appropriate because the study sought to test theoretically specified relationships among latent constructs related to Building Information Modeling adoption, including technological factors, organizational conditions, environmental pressures, and the moderating role of Corporate Culture, rather than relying exclusively on secondary descriptions or archival records, which would not have been sufficient for estimating the proposed structural relationships in the model, as explained in survey research and PLS-SEM methodology by Ponto (2015), Sekaran and Bougie (2019), and Hair et al. (2019). A structured questionnaire was therefore methodologically suitable because it allowed the collection of standardized responses from a professionally relevant group of respondents while preserving comparability across the constructs included in the conceptual model, which is particularly important in explanatory quantitative research based on latent variables and multivariate analysis, as noted by Sekaran and Bougie (2019) and Hair et al. (2019).

The questionnaire was prepared and administered through Google Forms as the principal data collection platform. This mode of administration was appropriate because it facilitated access to respondents across different professional roles and organizational settings within the Libyan construction sector, reduced geographical limitations, and enabled responses to be collected in a format suitable for later screening, coding, and statistical analysis, as supported by Evans and Mathur (2018) and Sekaran and Bougie (2019). The questionnaire link was distributed through professional and sector-related communication channels in order to reach participants with sufficient familiarity with construction practice and BIM-related organizational conditions. More specifically, the distribution process relied

on sector-relevant access routes, including construction-related offices, professional workplaces, WhatsApp, and other communication channels considered appropriate for reaching informed participants in the Libyan construction environment, in line with practical online-survey procedures discussed by Evans and Mathur (2018).

After the distribution stage, the returned questionnaires were reviewed and prepared for analysis through standard screening procedures. Responses were checked for usability, completeness, and internal consistency before inclusion in the final dataset used for descriptive analysis, measurement-model assessment, and structural-model testing, as recommended in quantitative research design and PLS-SEM reporting practice by Sekaran and Bougie (2019) and Hair et al. (2019). Only responses considered usable after this screening process were retained for the empirical analysis of the study. The achieved usable sample is reported later in Chapter Four under the respondent-profile section, where the final analytical dataset is presented in its finalized form after the completion of screening and data preparation procedures. Presenting the final usable sample at that stage, rather than in the present subsection, is methodologically appropriate because it preserves a clear distinction between the procedural logic of data collection and the empirical description of the finalized sample, as emphasized by Ponto (2015) and Hair et al. (2019).

Section 3.5 also serves an important interpretive function because it connects methodological planning with empirical realization. By clarifying that the final analytical dataset was obtained only after questionnaire distribution, return, review, and screening, the study avoids methodological confusion between intended sampling logic and achieved sample reality. This distinction is especially important in explanatory survey research, where the final dataset is shaped not only by access to respondents, but also by the quality and usability of the responses eventually returned, as explained by Ponto (2015) and Evans and Mathur (2018). In the context of the present study, such procedural clarity strengthens the credibility of the descriptive, measurement, and structural results reported later in Chapter Four, as also recommended by Hair et al. (2019) and Sekaran and Bougie (2019).

3.6.Measurement of Instruments

This study measured the constructs of the proposed model through a structured questionnaire composed of multiple items adapted from prior literature on BIM adoption, innovation adoption, institutional pressures, and organizational culture. All items were measured using a seven-point Likert scale ranging from 1 = strongly disagree to 7 = strongly

agree, because this response format is appropriate for capturing the degree of respondent agreement with construct-related statements in explanatory survey research (Sekaran & Bougie, 2019; Hair et al., 2019). The use of multi-item measures was necessary because the constructs examined in this study are latent variables that cannot be observed directly and therefore must be represented through several indicators reflecting their underlying conceptual domains (Hair et al., 2019; Ahmed & Kassem, 2018), as shown in Table 13.

Table 13: Seven-Point Likert Scale

1	2	3	4	5	6	7
Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree

To preserve consistency between the methodology chapter and the empirical analysis reported in the study, the number of items reported for each construct in this section follows the indicators retained and analyzed in the results chapter. Accordingly, Building Information Modeling adoption was measured with seven items, Corporate Culture with five items, Complexity with seven items, Relative Advantages with five items, Compatibility with four items, Top Management Support with five items, Organizational Readiness with four items, Mimetic Pressures with four items, Coercive Pressures with five items, and Normative Pressures with five items (Hair et al., 2019). This alignment is methodologically important because any discrepancy between the stated measurement model and the analyzed indicators would weaken the internal coherence of the study and create avoidable inconsistency between the methodology and results chapters (Hair et al., 2019).

3.6.1. Building Information Modeling Adoption

Building Information Modeling adoption was measured as an organizational-level construct reflecting the formal and practical uptake of BIM within the firm (Ahmed & Kassem, 2018; Succar, 2009). The measurement approach was designed to align with the view that BIM adoption should be captured through organizational commitment and embedded practice rather than through general awareness, isolated technical familiarity, or downstream project outcomes alone (Succar, 2009; Ahmed & Kassem, 2018). For that reason, the construct was measured through seven items that assess formal adoption decision, current project use, existence of procedures or guidelines, organizational-level support, future expansion intent, routinization of BIM in regular work, and the allocation of resources to sustain continued BIM use (Ahmed & Kassem, 2018; Ahuja et al., 2016). This measurement logic is appropriate because the study examines BIM adoption at the organizational level rather than individual

technology acceptance, and because BIM in construction organizations is more accurately understood as a structured innovation process involving institutional support, managerial continuity, and operational embedding within the firm (Succar, 2009; Ahmed & Kassem, 2018; Ahuja et al., 2016). Accordingly, the seven items presented in Table 14 were selected to capture organizational BIM adoption in a way that reflects commitment, deployment, institutionalization, and continuity of practice, which makes the dependent variable conceptually more precise and more consistent with the theoretical distinction between adoption, implementation, and use in the BIM literature (Ahmed & Kassem, 2018; Succar, 2009; Ahuja et al., 2016) , as shown in Table 14.

Table 14: Measurement items for Building Information Modeling Adoption

No.	Item
1	Our organization has formally decided to adopt BIM in its projects.
2	BIM is currently used in at least some projects in our organization.
3	Our organization has established clear procedures or guidelines for BIM use.
4	BIM use in our organization is supported at the organizational level rather than depending only on individual effort.
5	Our organization intends to expand BIM use in future projects.
6	BIM has become part of the regular way of working in our organization.
7	Our organization allocates resources to support the continued use of BIM.

Source: Adapted from Ahmed and Kassem (2018); Succar (2009); Ahuja et al. (2016).

3.6.2. Corporate Culture

Corporate Culture was incorporated in this study as a moderating variable, and its role was intentionally restricted to the relationship between Normative Pressures and BIM adoption only, consistent with the final conceptual model of the study (Alankarage et al., 2023; Behl et al., 2022; Dai et al., 2018). This restriction was conceptually necessary because the study does not assume that culture moderates all technological, organizational, and environmental relationships. Instead, it treats Corporate Culture as the internal interpretive condition most relevant to the way organizations respond to legitimacy-based and professionally endorsed external expectations (Alankarage et al., 2023; Tavallaei et al., 2022). The construct was measured through five items assessing whether the organization encourages openness to new

ways of working, supports learning and continuous improvement, promotes collaboration across functions, welcomes change initiatives, and reflects senior-management values supportive of innovation and organizational development. Accordingly, Corporate Culture in the present study refers to a general internal cultural condition rather than to a BIM-specific supportive climate, which makes the moderating construct more conceptually aligned with its theoretical role in the model (Alankarage et al., 2023; Dai et al., 2018; Behl et al., 2022).

Table 15: Measurement items for Corporate Culture

No.	Item
1	Our organization encourages openness to new ways of working.
2	Our organization supports learning and continuous improvement.
3	Employees in our organization are encouraged to collaborate across functions.
4	Change initiatives are generally welcomed in our organization.
5	Senior management promotes values that support innovation and organizational development.

Source: Adapted from the Alankarage et al. (2023), Behl et al. (2022), and Dai et al. (2018).

3.6.3. Complexity

Complexity was measured as the extent to which BIM-related demands are perceived as understandable, manageable, and capable of being handled within the organization without excessive procedural or operational difficulty (Shirowzhan et al., 2020; Ullah et al., 2022). In the present study, TCO refers to the perceived manageability of BIM-related complexity rather than to difficulty as a purely negative barrier. The construct was measured through seven items assessing whether BIM is reasonably understandable for employees, whether it can be integrated into existing work procedures without excessive difficulty, whether employees can handle BIM-related tasks without excessive mental burden, whether implementation is manageable for the organization, whether BIM software and related systems can be operated effectively, whether coordination across departments and project participants is manageable, and whether BIM can be introduced without severe operational disruption (Shirowzhan et al., 2020; Ullah et al., 2022). Accordingly, higher scores on TCO indicate stronger perceived manageability of BIM-related complexity within the organization, which is conceptually more

consistent with positive BIM adoption in the present study (Ahmed & Kassem, 2018; Succar, 2009).

Table 16: Measurement items for Complexity

No.	Item
1	BIM is reasonably understandable for employees in our organization.
2	BIM can be integrated into our existing work procedures without excessive difficulty.
3	Employees in our organization can handle BIM-related tasks without excessive mental burden.
4	BIM implementation is manageable for our organization.
5	BIM software and related systems can be operated effectively in our organization.
6	Coordinating BIM across departments and project participants is manageable in our organization.
7	Introducing BIM can be handled by our organization without severe operational disruption.

Source: Adapted from Ullah et al. (2022), Shirowzhan et al. (2020),

3.6.4. Relative Advantages

Relative Advantages refer to the extent to which BIM is perceived as offering superior value compared with traditional approaches to design, coordination, communication, and project information management (Ahuja et al., 2016; Wang et al., 2024). This construct is important because organizations are more likely to adopt BIM when they believe that it can improve project performance, information quality, process efficiency, and strategic competitiveness relative to conventional methods (Chowdhury et al., 2024; Ahmed & Kassem, 2018). In Table 17, Relative Advantages were measured through five items capturing the perceived benefits of BIM at the organizational and project levels.

Table 17: Measurement items for Relative Advantages

No.	Item
1	BIM improves coordination among project participants compared with traditional methods.
2	BIM improves the quality and consistency of project information.
3	BIM supports better project planning and decision making.
4	BIM improves overall project performance compared with conventional practices.
5	BIM enhances the competitive position of our organization in the construction sector.

Source: Adapted from Ahuja et al. (2016), Ahmed and Kassem (2018), and Wang et al. (2024).

3.6.5. Compatibility

Compatibility refers to the extent to which BIM is perceived as fitting the organization's existing workflows, routines, systems, and operational needs (Shirowzhan et al., 2020). In BIM research, compatibility is a crucial innovation attribute because adoption becomes more likely when the technology is perceived as manageable within the organization's current environment rather than as a disruptive intervention requiring excessive structural change (Shirowzhan et al., 2020). In Table 18, Compatibility was measured through four items.

Table 18: Measurement items for Compatibility

No.	Item
1	BIM is compatible with the way our organization currently works.
2	BIM fits our existing business and project operations.
3	BIM is compatible with our current technical and organizational systems.
4	BIM can be integrated into our existing workflows without excessive disruption.

Source: Adapted from Shirowzhan et al. (2020).

3.6.6. Top Management Support

Top Management Support refers to the degree to which senior organizational leaders endorse, legitimize, and actively support BIM adoption through strategic commitment, resource allocation, and visible managerial backing (Tavallaei et al., 2022; Villena-Manzanares

et al., 2021). This construct is particularly important in BIM adoption research because leadership commitment helps organizations move from awareness to coordinated implementation by signaling priority, reducing uncertainty, and mobilizing internal effort (Tavallaei et al., 2022; Villena-Manzanares et al., 2021). In Table 19, Top Management Support was measured using five items.

Table 19: Measurement items for Top Management Support

No.	Item
1	Top management actively promotes the use of BIM in our projects.
2	Top management allocates sufficient resources for BIM training and implementation.
3	The leadership communicates the benefits of BIM adoption effectively to all levels of the organization.
4	Top management is involved in planning and monitoring BIM adoption processes.
5	Top management provides ongoing support to resolve issues arising from BIM adoption.
6	Top management would think that my company should implement BIM.
7	Top management supports adequate time and resource allocations for the BIM implementation
8	Top management considers BIM important

Source: Adapted from Tavallaei et al. (2022) and Villena-Manzanares et al. (2021).

3.6.7. Organizational Readiness

Organizational Readiness refers to the extent to which the organization possesses the internal capacity and preparedness required to adopt BIM successfully, including knowledge, skills, processes, and supporting conditions (Magalhães et al., 2023; Phung & Tong, 2021). In BIM adoption research, readiness is a critical construct because organizations may recognize the value of BIM while still lacking the capability to operationalize it in a coherent and sustained way (Magalhães et al., 2023). In Table 20, Organizational Readiness was measured through four items.

Table 20: Measurement items for Organizational Readiness

No.	Item
1	Our firm knows how information technology can be used to support our operations.
2	Our firm has a good understanding of how digital technologies can be used in our business.
3	We have the necessary technical and managerial skills to implement BIM.
4	Our organization has the internal conditions needed to support BIM adoption effectively.

Source: Adapted from Ifinedo (2011), and refined in line with Magalhães et al. (2023) and Phung and Tong (2021).

3.6.8. Mimetic Pressures

Mimetic Pressures refer to the pressure felt by organizations to imitate other organizations that are perceived as successful, legitimate, or strategically advanced, especially under conditions of uncertainty (DiMaggio & Powell, 1983; Tavallaei et al., 2022). In BIM adoption settings, such pressure arises when firms observe competitors, consultants, or peer organizations benefiting from BIM and therefore feel encouraged to follow similar practices (Cao et al., 2014). In Table 21, Mimetic Pressures were measured with four items.

Table 21: Measurement items for Mimetic Pressures

No.	Item
1	Peer projects that have adopted BIM have benefited greatly.
2	Peer projects that have adopted BIM are perceived favorably by others in the industry.
3	Peer projects that have adopted BIM have gained a good reputation in the industry.
4	Our organization tends to adopt BIM in order to keep up with competitors using BIM.

Source: Adapted from Cao, Li, and Wang (2014).

3.6.9. Coercive Pressures

Coercive Pressures refer to the external pressures arising from formal authority, dependency relationships, contractual expectations, regulatory requirements, or the demands of powerful stakeholders such as governments, clients, and industry bodies (DiMaggio &

Powell, 1983; Tavallaei et al., 2022). In the BIM context, coercive pressure is often expressed through mandates, contractual specifications, procurement rules, or project conditions that make BIM adoption more difficult to ignore (Cao et al., 2014). In Table 22, Coercive Pressures were measured through five items.

Table 22: Measurement items for Coercive Pressures

No.	Item
1	Regulatory requirements compel us to adopt BIM.
2	Client specifications often mandate the use of BIM in projects.
3	Government requirements encourage or compel BIM use in our projects.
4	Industry associations create pressure for BIM adoption in our projects.

Source: Adapted from Cao, Li, and Wang (2014), and aligned with institutional-pressure literature in BIM adoption.

3.6.10. Normative Pressures

Normative Pressures refer to the influence of professional norms, expert discourse, educational institutions, industry associations, and shared expectations regarding what constitutes legitimate and appropriate practice in the construction field (DiMaggio & Powell, 1983; Tavallaei et al., 2022). Among the environmental factors, Normative Pressures are especially important in this study because Corporate Culture is theorized to moderate only the relationship between Normative Pressures and BIM adoption (Alankarage et al., 2023; Tavallaei et al., 2022). To maintain full consistency with the empirical analysis reported in Table 23, Normative Pressures are specified here as a five-item construct.

Table 23: Measurement items for Normative Pressures

No.	Item
1	Software vendors strongly advocate the adoption of BIM in our types of projects.
2	Industry consultants strongly advocate the adoption of BIM in our types of projects.
3	Universities and academic institutions strongly advocate BIM adoption in our field.

4	Industry associations strongly promote the value of BIM in our types of projects.
5	Professional training and industry education increasingly present BIM as a standard and appropriate practice.

Source: Adapted from Cao, Li, and Wang (2014), and refined in line with Tavallaei et al. (2022).

3.7. Data Analysis Procedure

The analysis of the data in this study was carried out using two complementary statistical software packages, namely IBM SPSS Statistics version 26 and SmartPLS, because the study required both preliminary statistical examination and latent-variable structural modeling (Hair et al., 2019; Pallant, 2020). The use of two software environments was methodologically appropriate because the research design combined respondent profiling, descriptive statistical analysis, correlation analysis, and the evaluation of a reflective measurement and structural model based on multiple latent constructs (Hair et al., 2019; Ponto, 2015). This analytical structure is consistent with the objective of the study, which is to examine the relationships between Complexity, Relative Advantages, Compatibility, Top Management Support, Organizational Readiness, Mimetic Pressures, Coercive Pressures, and Normative Pressures and BIM adoption, while testing Corporate Culture as a focused moderator of the relationship between Normative Pressures and BIM adoption only (DiMaggio & Powell, 1983; Tavallaei et al., 2022; Alankarage et al., 2023).

3.7.1. Preliminary Data Screening and Reliability Analysis

In addition to screening the dataset for usability, completeness, and consistency, common method bias was also treated as a potential source of distortion that should be considered when interpreting the results of the study, because the data were obtained through a single cross-sectional questionnaire and all principal constructs were measured through the same survey instrument (Pallant, 2020; Ponto, 2015). At this stage, the main objective was not to claim that method effects had been eliminated completely, but to recognize that survey-based studies of this kind may contain some degree of shared method-related variance and that the empirical findings should therefore be interpreted with appropriate methodological caution, particularly in relation to the magnitude and consistency of the observed relationships among the constructs (Podsakoff et al., 2003; Hair et al., 2019). This clarification strengthens the methodological transparency of the study because it acknowledges an important issue in

behavioral and organizational survey research without overstating the ability of a single design feature to remove it completely (Podsakoff et al., 2003; Ponto, 2015).

3.7.2. Descriptive Statistical Analysis

After preliminary screening and reliability checking, descriptive statistical analysis was performed using IBM SPSS Statistics version 26 (Pallant, 2020). Descriptive statistics are important in quantitative survey research because they summarize the characteristics of the sample and provide a clear initial picture of the response pattern for each measured item and construct (Ponto, 2015; Pallant, 2020). In the present study, descriptive statistics were used to summarize the demographic characteristics of the respondents and to describe the central tendency and dispersion of the study variables through frequencies, percentages, means, and standard deviations (Pallant, 2020; Ponto, 2015).

3.7.3. Correlation, Skewness, and Kurtosis Analysis

The next stage of the analysis involved the use of SPSS to examine correlation coefficients among the study variables and to assess the distributional characteristics of the data through skewness and kurtosis statistics (Pallant, 2020). Correlation analysis is useful because it provides an initial indication of the direction and strength of association among variables before they are tested in a more comprehensive structural model (Hair et al., 2019; Pallant, 2020). Skewness provides information about the symmetry of the distribution, whereas kurtosis indicates the extent to which the distribution is more peaked or flatter than a normal distribution (Pallant, 2020). Even though PLS-SEM does not require strict multivariate normality in the same way as covariance-based SEM, reporting skewness and kurtosis remains methodologically useful because it strengthens transparency in the data-screening process (Hair et al., 2019).

3.7.4. Measurement Model Assessment

After the SPSS-based preliminary analysis, the next analytical stage involved measurement-model assessment using SmartPLS (Hair et al., 2019). This stage was necessary because the study is based on latent constructs that cannot be observed directly and therefore must be evaluated through their indicators before structural relationships among constructs can be interpreted meaningfully (Hair et al., 2019). In reflective measurement models, the adequacy of the constructs must be established by examining internal consistency reliability, convergent validity, and discriminant validity (Hair et al., 2019). Internal consistency reliability in the measurement model was assessed through Cronbach's alpha and composite reliability.

Convergent validity was assessed through indicator loadings and the average variance extracted, while discriminant validity was evaluated through the Fornell-Larcker criterion, cross-loadings, and the heterotrait-monotrait ratio of correlations (Fornell & Larcker, 1981; Henseler et al., 2015; Hair et al., 2019).

3.7.5. Structural Model Assessment and Hypothesis Testing

Once the adequacy of the measurement model had been established, the study proceeded to structural-model assessment and hypothesis testing using SmartPLS (Hair et al., 2019). Structural-model assessment is required in PLS-SEM because the research objective is not limited to validating the measurement of constructs, but extends to examining the relationships among those constructs in accordance with the conceptual framework and research hypotheses (Hair et al., 2019). The first part of the structural-model assessment involved examining collinearity among the predictor constructs through variance inflation factor values because high collinearity can distort path estimates and reduce the stability of the model (Hair et al., 2019; Kock, 2015). The second part involved estimating the path coefficients associated with the proposed hypotheses and testing their statistical significance through bootstrapping (Hair et al., 2019). The final part of this stage involved moderation analysis, carried out only for the interaction between Corporate Culture and Normative Pressures in predicting BIM adoption, because this is the only moderated relationship specified in the final conceptual model of the study (Tavallaei et al., 2022; Alankarage et al., 2023).

3.8. Summary of Chapter

This chapter has presented the methodological framework adopted for examining the relationship between technological, organizational, and environmental factors and Building Information Modeling adoption in the Libyan construction sector, with Corporate Culture specified as a moderator of the relationship between Normative Pressures and BIM adoption only. The chapter explained the philosophical and methodological basis of the study by identifying positivism as the guiding research philosophy, deduction as the research approach, and a quantitative cross-sectional survey as the overall research design. It also clarified the study context, target population, unit of analysis, sampling strategy, and data collection procedure through an online questionnaire distributed to relevant construction professionals in Libya. In addition, the chapter described the operationalization of all study constructs and explained the analytical procedure used for preliminary statistical analysis in SPSS and measurement-model and structural-model testing in SmartPLS. Through these steps, the

chapter established a coherent methodological basis for testing the hypotheses of the study in a rigorous and context-appropriate manner.

4. CHAPTER FOUR: RESULTS AND FINDINGS

4.1. Introduction

This chapter presents the empirical results of the study on the relationship between technological, organizational, and environmental factors and Building Information Modeling adoption in the Libyan construction sector. Consistent with the final conceptual model of the study, BIM is treated as the dependent variable, while TCO, TRA, and TCOM represent the technological antecedents, OTMS and OOR represent the organizational antecedents, and EMP, ECP, and ENP represent the environmental antecedents. In addition, CC is examined as a moderating variable that conditions only the relationship between ENP and BIM, rather than acting as a direct predictor across the full model. This structure follows the theoretical and methodological boundaries established in the previous chapters of the study. The chapter translates the conceptual and methodological design of the study into empirical evidence. It reports the statistical findings required to determine whether the proposed relationships are supported by the data collected from professionals in the Libyan construction sector. The analysis is based on 389 usable responses retained after the data-screening process. In line with the analytical procedure defined in the methodology chapter, the results are presented in a structured sequence that begins with the profile of the respondents, followed by the descriptive statistics of the study constructs, correlation analysis, preliminary assessment of data distribution, and the evaluation of the measurement model. The chapter then proceeds to the structural model assessment, hypothesis testing, and the evaluation of the explanatory power and model fit of the proposed model. In this way, the chapter provides the empirical basis for the discussion and conclusion developed in the following chapter.

4.2. Profile of Respondents

This section presents the profile of the respondents included in the empirical analysis of the study. Reporting respondent characteristics is methodologically important because the present research examines Building Information Modeling adoption through the responses of professionals working in the Libyan construction sector who are expected to possess relevant organizational, technical, and sectoral knowledge, rather than through anonymous general-public opinion, as noted in survey research by Ponto (2015) and reflected in BIM-related organizational studies such as Elghdhan et al. (2023). In line with the data collection and

screening procedures described in Chapter Three, the final usable sample consisted of 389 respondents. The profile information reported in this section therefore provides an essential contextual basis for interpreting the descriptive statistics, the measurement model, and the structural model, since variation in age, gender, educational attainment, job role, work experience, organizational setting, and BIM familiarity may shape how respondents perceive the constructs examined in the study, as discussed by Sekaran and Bougie (2019) and Ponto (2015).

The achieved sample reflects a professionally diverse group of respondents from the Libyan construction sector. The profile table shows representation across multiple age groups, educational levels, job positions, organizational types, organization sizes, levels of BIM familiarity, and BIM implementation status. This diversity is methodologically important because it indicates that the dataset captures evidence from respondents occupying different professional and organizational locations within the sector rather than from one narrowly defined occupational category alone, which strengthens the interpretive value of the findings, as suggested by Ponto (2015) and supported by the organizational focus of BIM adoption research in Elghdhan et al. (2023) and Tavallaei et al. (2022). Such diversity is substantively valuable because BIM adoption is associated with organizational and institutional conditions that may be experienced differently across roles, settings, and levels of exposure to digital construction practices, as reflected in the wider BIM literature and in Libyan-context studies such as Elghdhan et al. (2023).

More specifically, the respondent profile shows representation from active professional age groups, multiple educational levels, and a wide range of occupational positions, including engineers, consultants, project managers, contractors or subcontractors, BIM specialists, and architects. The organizational profile also indicates participation from public-sector organizations, private-sector organizations, and joint ventures, as well as organizations of different sizes and respondents with varying levels of BIM familiarity and implementation exposure. Taken together, these characteristics indicate that the respondent base was sufficiently broad and professionally relevant to support the aims of the study and to provide a credible empirical foundation for the subsequent statistical analysis. In methodological terms, this diversity does not imply statistical representativeness in a strict census sense, because the study employed purposive sampling rather than probability-based national enumeration, but it does enhance the relevance, contextual grounding, and interpretive value of the findings

reported in Chapter Four, as explained by Ponto (2015), Palinkas et al. (2015), and Elghdhan et al. (2023).

Table 24: Profile of Respondents

Variable	Category	Frequency	Percentage
Age	Under 25	28	7.2
	25–34	97	24.9
	35–44	117	30.1
	45–54	89	22.9
	55 and above	58	14.9
Gender	Male	296	76.09
	Female	93	23.91
Highest Level of Education	High School Diploma or equivalent	52	13.4
	Vocational/Technical Diploma	63	16.2
	Bachelor’s Degree	171	44.0
	Master’s Degree	85	21.8
	Doctorate (PhD)	18	4.6
Job Title/Position	Engineer	102	26.2
	Architect	18	4.6
	Project Manager	58	14.9
	Contractor/Subcontractor	49	12.6
	BIM Specialist	45	11.6
	Consultant	117	30.1
	Job Experience	Less than 1 year	19
1–5 years	82	21.1	
6–10 years	101	26.0	
11–15 years	92	23.6	
More than 15 years	95	24.4	
Type of Organization	Public Sector	108	27.8
	Private Sector	249	64.0
	Joint Venture	32	8.2
Size of the Organization	Less than 10 employees	21	5.4
	10–49 employees	69	17.7
	50–99 employees	91	23.4
	100–249 employees	109	28.0
	250 and above	99	25.5
BIM Implementation Status	Yes	231	59.4
	No	118	30.3
	Not sure	40	10.3
Level of BIM Familiarity	Not familiar at all	41	10.5
	Slightly familiar	72	18.5
	Moderately familiar	103	26.5
	Very familiar	102	26.2
	Expert level	71	18.3

Note. N = 389.

Source. Developed by the researcher based on the survey data.

Table 24 shows that the achieved sample reflects a professionally diverse group of respondents from the Libyan construction sector. The largest age group was 35 to 44 years, followed by 25 to 34 years and 45 to 54 years, which indicates that most respondents were in active professional and managerial stages of their careers. The sample was predominantly male, which is consistent with the general structure of the construction industry in Libya. In terms of education, most respondents held a bachelor’s degree, followed by master’s degree holders,

which suggests that the sample was largely composed of formally educated professionals capable of evaluating the organizational and technological issues addressed in this study. The occupational distribution also supports the analytical value of the sample, as consultants, engineers, and project managers formed the largest groups, alongside contractors, BIM specialists, and architects. This means that the responses were obtained from participants involved in planning, design, coordination, management, and implementation activities across the construction process.

Table 24 also indicates that the sample included respondents with substantial professional experience and representation from different organizational settings. The largest shares were found in the categories of 6 to 10 years, 11 to 15 years, and more than 15 years of work experience, which strengthens confidence in the practical relevance of the responses. Most respondents worked in private-sector organizations, followed by public-sector institutions and joint ventures. In addition, a considerable share of the respondents came from medium-sized and large organizations, particularly those employing 100 to 249 employees and 250 employees or more. From a BIM-related perspective, more than half of the respondents reported that they or their organizations had implemented BIM in at least some projects, while a substantial proportion described themselves as very familiar with BIM or at expert level. Taken together, these results suggest that the sample was suitable for examining BIM adoption in the Libyan construction sector and provides a credible empirical basis for the subsequent statistical analyses.

4.3. Descriptive Statistics of the Study Constructs

This section presents the descriptive statistics of the study constructs using the mean and standard deviation values for each measurement item and for each construct as a whole. The purpose of this section is to provide an initial empirical overview of how the respondents evaluated the technological, organizational, environmental, moderating, and dependent constructs included in the study. The mean values indicate the general tendency of responses for each item, while the standard deviation values show the degree of dispersion in respondents' views. Together, these indicators provide a useful preliminary picture of the relative strength and stability of the constructs before proceeding to correlation analysis, measurement model assessment, and structural model testing.

4.3.1. Complexity (TCO)

The descriptive statistics for Complexity should be interpreted in light of the study's operational meaning of TCO. In the present study, TCO refers to the perceived manageability

of BIM-related complexity rather than to complexity as a purely inhibiting barrier. Therefore, higher mean values on this construct indicate that respondents perceived BIM-related demands as more understandable, more manageable, and more capable of being integrated into organizational practice without excessive disruption or burden (Shirowzhan et al., 2020; Ullah et al., 2022). In this sense, the descriptive results for TCO reflect the degree to which BIM-related complexity is viewed as manageable within the organization, which is conceptually consistent with stronger organizational BIM adoption in the present study (Ahmed & Kassem, 2018; Succar, 2009).

Table 25: Descriptive Statistics for Complexity (TCO)

Item	Mean	Standard Deviation
TCO_item1	3.699	1.038
TCO_item2	3.429	0.997
TCO_item3	3.661	1.027
TCO_item4	3.416	0.975
TCO_item5	4.108	1.059
TCO_item6	3.712	1.0
TCO_item7	4.026	1.098
TCO_items	3.722	0.883

Source. Developed by the researcher based on the survey data.

Table 25 shows that the overall mean for Complexity was 3.722, with a standard deviation of 0.883, indicating a moderate level of perceived complexity in relation to BIM adoption. Among the individual items, TCO_item5 recorded the highest mean value of 4.108, followed by TCO_item7 with a mean of 4.026, which suggests that some dimensions of BIM were perceived as more complex than others. In contrast, TCO_item4 and TCO_item2 produced the lowest mean scores, at 3.416 and 3.429 respectively, indicating relatively lower agreement on those aspects. The standard deviation values ranged from 0.975 to 1.098, which suggests a moderate spread in responses and indicates that respondents differed to some extent in how strongly they perceived BIM-related complexity.

4.3.2. Relative Advantages (TRA)

This subsection presents the descriptive statistics for Relative Advantages, measured through five items. Relative Advantages refer to the degree to which BIM is perceived as offering benefits that are superior to conventional methods and practices. The descriptive results help identify whether respondents generally recognized BIM as a beneficial innovation in the Libyan construction context.

Table 26: Descriptive Statistics for Relative Advantages (TRA)

Item	Mean	Standard Deviation
TRA_item1	3.959	1.13

Item	Mean	Standard Deviation
TRA_item2	3.643	1.079
TRA_item3	3.568	1.017
TRA_item4	3.951	1.087
TRA_item5	3.954	1.095
TRA_items	3.815	0.973

Source. Developed by the researcher based on the survey data.

Table 26 indicates that the overall mean for Relative Advantages was 3.815, with a standard deviation of 0.973, reflecting a moderately positive perception of BIM's advantages over traditional approaches. The highest mean value was observed for TRA_item1 at 3.959, followed closely by TRA_item5 and TRA_item4, with mean values of 3.954 and 3.951 respectively. This suggests that respondents tended to acknowledge a number of beneficial aspects associated with BIM. By contrast, TRA_item3 recorded the lowest mean value of 3.568, followed by TRA_item2 at 3.643, indicating comparatively weaker agreement on some benefit-related aspects. The standard deviation values ranged from 1.017 to 1.130, showing moderate variability in respondents' evaluations of BIM's relative advantages.

4.3.3. Compatibility (TCOM)

This subsection reports the descriptive statistics for Compatibility, measured through four items. Compatibility refers to the extent to which BIM is perceived as fitting existing work practices, organizational systems, and operational requirements. Assessing the mean and standard deviation values of the TCOM items provides an early indication of whether BIM is viewed as practically aligned with the current conditions of the Libyan construction sector.

Table 27: Descriptive Statistics for Compatibility (TCOM)

Item	Mean	Standard Deviation
TCOM_item1	3.889	1.055
TCOM_item2	4.054	1.089
TCOM_item3	4.069	1.044
TCOM_item4	4.134	1.032
TCOM_items	4.037	0.962

Source. Developed by the researcher based on the survey data.

Table 27 shows that the overall mean for Compatibility was 4.037, with a standard deviation of 0.962, indicating a generally favorable perception of BIM compatibility among the respondents. The highest mean was reported for TCOM_item4 at 4.134, followed by TCOM_item3 and TCOM_item2, with mean values of 4.069 and 4.054 respectively. These results suggest that respondents tended to view BIM as reasonably compatible with existing organizational and technical practices. TCOM_item1 produced the lowest mean value, 3.889, although it still remained close to the general pattern of moderate agreement. The standard deviation values ranged from 1.032 to 1.089, reflecting moderate variation in the responses.

4.3.4. Top Management Support (OTMS)

This subsection presents the descriptive statistics for Top Management Support, measured through eight items in the current results set. Top Management Support reflects the degree to which organizational leadership provides commitment, direction, and support for BIM adoption. Reviewing these values is important because managerial backing is often a critical condition for successful innovation adoption at the organizational level.

Table 28: Descriptive Statistics for Top Management Support (OTMS)

Item	Mean	Standard Deviation
OTMS_item1	3.879	1.097
OTMS_item2	4.188	1.02
OTMS_item3	4.252	1.069
OTMS_item4	3.843	1.121
OTMS_item5	3.987	1.132
OTMS_item6	4.134	1.132
OTMS_item7	4.057	1.129
OTMS_item8	4.306	1.058
OTMS_items	4.083	0.985

Source. Developed by the researcher based on the survey data.

Table 28 indicates that the overall mean for Top Management Support was 4.083, with a standard deviation of 0.985, suggesting a moderately strong perception that organizational leadership supports BIM adoption. OTMS_item8 recorded the highest mean value at 4.306, followed by OTMS_item3 at 4.252 and OTMS_item2 at 4.188. This indicates that some aspects of managerial support were evaluated quite positively by the respondents. In contrast, OTMS_item4 and OTMS_item1 recorded the lowest means, at 3.843 and 3.879 respectively, suggesting that support may not be equally strong across all dimensions. The standard deviation values ranged from 1.020 to 1.132, which indicates moderate diversity in respondents' views regarding managerial support.

4.3.5. Organizational Readiness (OOR)

This subsection reports the descriptive statistics for Organizational Readiness, measured through four items. Organizational Readiness refers to the extent to which the organization is prepared in terms of resources, willingness, and capability to adopt BIM. The descriptive analysis helps show whether respondents generally viewed their organizations as sufficiently prepared for BIM implementation.

Table 29: Descriptive Statistics for Organizational Readiness (OOR)

Item	Mean	Standard Deviation
OOR_item1	4.108	1.079
OOR_item2	4.046	1.134
OOR_item3	3.979	1.121
OOR_item4	4.121	1.128

Item	Mean	Standard Deviation
OOR_items	4.064	1.006

Source. Developed by the researcher based on the survey data.

Table 29 shows that the overall mean for Organizational Readiness was 4.064, with a standard deviation of 1.006, indicating a moderately positive assessment of readiness for BIM adoption. OOR_item4 recorded the highest mean value at 4.121, followed closely by OOR_item1 at 4.108. These findings suggest that respondents tended to view some readiness-related aspects favorably. OOR_item3 recorded the lowest mean value at 3.979, though this still reflects a generally moderate level of agreement. The standard deviation values ranged from 1.079 to 1.134, which suggests moderate variability across respondents' perceptions of organizational readiness.

4.3.6. Mimetic Pressures (EMP)

This subsection presents the descriptive statistics for Mimetic Pressures, measured through four items. Mimetic Pressures refer to the tendency of organizations to imitate the practices of other organizations perceived as successful, legitimate, or influential. The descriptive results provide an initial indication of whether such pressures are meaningfully perceived in the Libyan construction sector.

Table 30: Descriptive Statistics for Mimetic Pressures (EMP)

Item	Mean	Standard Deviation
EMP_item1	3.974	1.012
EMP_item2	4.018	1.027
EMP_item3	4.177	1.019
EMP_item4	3.913	1.066
EMP_items	4.021	0.93

Source. Developed by the researcher based on the survey data.

Table 30 indicates that the overall mean for Mimetic Pressures was 4.021, with a standard deviation of 0.930, suggesting a moderately positive perception of imitation-based external influence. EMP_item3 recorded the highest mean value at 4.177, indicating relatively stronger agreement on that aspect of mimetic pressure. EMP_item2 and EMP_item1 followed with mean values of 4.018 and 3.974 respectively. The lowest mean value was observed for EMP_item4 at 3.913, although it remained within the same general range. The standard deviation values ranged from 1.012 to 1.066, which indicates moderate dispersion and suggests that respondents did not evaluate mimetic pressures in a fully uniform way.

4.3.7. Coercive Pressures (ECP)

This subsection reports the descriptive statistics for Coercive Pressures, measured through four items. Coercive Pressures refer to formal or informal pressures arising from powerful actors such as regulators, clients, or dominant organizations that may influence BIM adoption decisions. The descriptive results help clarify the extent to which respondents perceived such pressures in the Libyan construction environment.

Table 31: Descriptive Statistics for Coercive Pressures (ECP)

Item	Mean	Standard Deviation
ECP_item1	3.658	1.062
ECP_item2	3.787	1.007
ECP_item3	4.247	1.101
ECP_item4	4.062	0.929
ECP_items	3.938	0.923

Source. Developed by the researcher based on the survey data.

Table 31 shows that the overall mean for Coercive Pressures was 3.938, with a standard deviation of 0.923, indicating a moderately positive but not especially strong perception of coercive influences on BIM adoption. The highest mean value was recorded for ECP_item3 at 4.247, followed by ECP_item4 at 4.062, suggesting that some forms of coercive pressure were recognized more clearly than others. In contrast, ECP_item1 had the lowest mean value at 3.658, indicating weaker agreement on that specific aspect. The standard deviation values ranged from 0.929 to 1.101, which suggests moderate variability across the responses.

4.3.8. Normative Pressures (ENP)

This subsection presents the descriptive statistics for Normative Pressures, measured through five items. Normative Pressures refer to professional norms, accepted standards, and shared expectations that may encourage organizations to adopt BIM as an appropriate way of operating. This construct is particularly important in the present study because it is also involved in the moderation relationship with Corporate Culture.

Table 32: Descriptive Statistics for Normative Pressures (ENP)

Item	Mean	Standard Deviation
ENP_item1	3.828	0.976
ENP_item2	4.077	0.976
ENP_item3	3.612	1.041
ENP_item4	3.568	0.978
ENP_item5	4.622	0.799
ENP_items	3.941	0.703

Source. Developed by the researcher based on the survey data.

Table 32 indicates that the overall mean for Normative Pressures was 3.941, with a standard deviation of 0.703, suggesting a relatively stable and moderately positive perception of normative influences related to BIM adoption. ENP_item5 recorded the highest mean value at 4.622 and the lowest standard deviation at 0.799, indicating comparatively strong and consistent agreement among respondents on that item. ENP_item2 also showed a relatively high mean value of 4.077. By contrast, ENP_item4 and ENP_item3 had lower mean values of 3.568 and 3.612 respectively, indicating that not all aspects of normative pressure were perceived equally strongly. Overall, the relatively low standard deviation of the construct suggests more consistency in responses than was observed for several other constructs.

4.3.9. Corporate Culture (CC)

The descriptive statistics for Corporate Culture should be interpreted in light of the study's revised operational meaning of the construct. In the present study, Corporate Culture refers to a general internal cultural condition reflecting openness to new ways of working, support for learning and continuous improvement, encouragement of collaboration across functions, receptiveness to change initiatives, and senior-management values supportive of innovation and organizational development, rather than to a BIM-specific supportive attitude alone (Alankarage et al., 2023; Dai et al., 2018; Behl et al., 2022). Accordingly, higher mean values on this construct indicate that respondents perceived their organizations as having a stronger internal cultural environment supportive of learning, collaboration, innovation, and change-oriented organizational development. In this sense, the descriptive results for Corporate Culture reflect the degree to which the organization possesses an internal cultural condition that may strengthen its responsiveness to external professional and legitimacy-based pressures related to BIM adoption, which is consistent with the theoretical role assigned to the construct in the present study (Alankarage et al., 2023; Dai et al., 2018; Behl et al., 2022).

Table 33: Descriptive Statistics for Corporate Culture (CC)

Item	Mean	Standard Deviation
CC_item1	4.121	1.025
CC_item2	3.774	1.031
CC_item3	4.334	1.07
CC_item4	4.031	1.166
CC_item5	4.1	1.111
CC_items	4.072	0.974

Source. Developed by the researcher based on the survey data.

Table 33 shows that the overall mean for Corporate Culture was 4.072, with a standard deviation of 0.974, indicating a moderately favorable perception of the organizational cultural

environment. CC_item3 recorded the highest mean value at 4.334, suggesting relatively stronger agreement on that cultural dimension. CC_item1 and CC_item5 also showed high mean values of 4.121 and 4.100 respectively. In contrast, CC_item2 recorded the lowest mean at 3.774, indicating comparatively weaker agreement on that aspect of corporate culture. The standard deviation values ranged from 1.025 to 1.166, suggesting moderate variability in how respondents assessed their organizational culture.

4.3.10. Building Information Modeling Adoption (BIM)

This subsection presents the descriptive statistics for the dependent variable, Building Information Modeling Adoption, measured through seven items. The purpose of this analysis is to provide an initial overview of how respondents evaluated the status and extent of BIM adoption in the Libyan construction sector.

Table 34: Descriptive Statistics for Building Information Modeling Adoption (BIM)

Item	Mean	Standard Deviation
BIM_item1	3.725	1.042
BIM_item2	3.859	1.143
BIM_item3	3.848	1.173
BIM_item4	3.748	1.062
BIM_item5	3.799	1.11
BIM_item6	3.846	0.909
BIM_item7	3.807	1.089
BIM_items	3.804	0.97

Source. Developed by the researcher based on the survey data.

Table 34 indicates that the overall mean for BIM Adoption was 3.804, with a standard deviation of 0.970, suggesting a moderate level of BIM adoption as perceived by the respondents. BIM_item2 recorded the highest mean value at 3.859, followed closely by BIM_item3 at 3.848 and BIM_item6 at 3.846. This indicates that respondents tended to express moderate agreement regarding several aspects of BIM adoption. BIM_item1 recorded the lowest mean value at 3.725, followed by BIM_item4 at 3.748, suggesting relatively lower agreement on those items. The standard deviation values ranged from 0.909 to 1.173, indicating moderate variability across the responses. Overall, the results suggest that BIM adoption in the Libyan construction sector was perceived at a moderate level rather than at a strongly established level.

4.4. Correlation Analysis Among the Study Constructs

This section presents the correlation matrix among the main constructs of the study. Correlation analysis is useful at this stage because it provides an initial statistical indication of the direction and strength of the associations among the variables before proceeding to the

assessment of the measurement model and the structural model. In the present study, the correlation matrix is used to examine the bivariate relationships between BIM adoption and the technological, organizational, environmental, and moderating constructs included in the final model, namely TCO, TRA, TCOM, OTMS, OOR, EMP, ECP, ENP, and CC (Hair et al., 2022; Henseler et al., 2016).

Table 35: Correlation Coefficients Among the Study Constructs

Latent Variables	BIM	CC	ECP	EMP	ENP	OOR	OTMS	TCO	TCOM	TRA
BIM	1									
CC	0.636*	1								
ECP	0.087*	-0.053	1							
EMP	0.169*	0.005	-0.073	1						
ENP	0.519*	0.033	-0.001	0.010	1					
OOR	0.112*	0.002	0.034	0.035	0.059	1				
OTMS	0.122*	0.068	-0.008	-0.029	-0.065	-0.036	1			
TCO	0.116*	-0.022	0.098	-0.029	0.017	-0.026	-0.008	1		
TCOM	0.057*	-0.016	-0.059	0.053	-0.055	-0.066	-0.002	-0.031	1	
TRA	0.249*	0.089	-0.044	0.086	0.031	-0.029	0.005	0.040	-0.009	1

Note. * $p < 0.001$.

Source. Developed by the researcher based on the survey data.

Table 35 shows that BIM adoption was positively correlated with all the main constructs in the study, although the strength of these correlations varied considerably. The strongest positive correlation was found between BIM and CC, with a coefficient of 0.636, followed by the correlation between BIM and ENP, with a coefficient of 0.519. These two results indicate that BIM adoption was more strongly associated with Corporate Culture and Normative Pressures than with the remaining constructs at the bivariate level. TRA also showed a positive correlation with BIM, with a coefficient of 0.249, while EMP showed a smaller but still positive correlation of 0.169. Similarly, OTMS, TCO, and OOR were positively associated with BIM, with coefficients of 0.122, 0.116, and 0.112 respectively. ECP also showed a weak positive correlation with BIM at 0.087, whereas TCOM had the weakest positive correlation with BIM at 0.057. From an analytical perspective, these coefficients provide only preliminary evidence of association and should not be interpreted as causal effects, since causal assessment in PLS-SEM depends on the subsequent structural model analysis rather than on bivariate correlations alone (Hair et al., 2019; Hair et al., 2022).

4.5. Kurtosis and Skewness of the Study Variables

This section presents the kurtosis and skewness values of the main study constructs in order to assess the distributional characteristics of the data before proceeding to the evaluation of the measurement model and the structural model. Skewness indicates the degree of

symmetry in the distribution of responses, whereas kurtosis reflects the extent to which the distribution is more peaked or flatter than the normal distribution. In PLS-SEM and related multivariate procedures, examining these two indicators is a standard preliminary step because it helps determine whether the observed data deviate substantially from normality and whether any severe distributional problems may affect subsequent statistical interpretation (Hair et al., 2019).

Table 36: Kurtosis and Skewness of the Study Variables

Latent Variables	Kurtosis	Skewness	N
TCO_items	0.461	0.241	389
TRA_items	-0.12	0.139	389
TCOM_items	0.056	-0.018	389
OTMS_items	-0.218	0.019	389
OOR_items	-0.037	-0.007	389
EMP_items	0.231	-0.062	389
ECP_items	-0.082	0.025	389
ENP_items	0.621	0.232	389
CC_items	-0.292	-0.101	389
BIM_items	-0.065	0.217	389

Source. Developed by the researcher based on the survey data.

Table 36 shows that the skewness values for all constructs ranged from -0.101 to 0.241, while the kurtosis values ranged from -0.292 to 0.621. These values are all close to zero and remain well within commonly accepted guideline ranges for approximate normality in multivariate research. In practical terms, this indicates that none of the constructs exhibited serious asymmetry or excessive peakedness and that the response distributions were reasonably well behaved. According to widely used methodological guidance, absolute skewness and kurtosis values greater than 1 signal nonnormality, whereas values within that range are generally considered acceptable for preliminary screening purposes (Hair et al., 2019).

A closer examination shows that ENP_items recorded the highest kurtosis value, 0.621, and a positive skewness value of 0.232, indicating a mildly peaked and slightly right-skewed distribution. By contrast, CC_items showed the lowest kurtosis value, -0.292, and a skewness value of -0.101, suggesting a slightly flatter and marginally left-skewed distribution. The remaining constructs clustered even more closely around zero, which further supports the conclusion that the data did not suffer from any meaningful univariate distributional distortion. Overall, the kurtosis and skewness results indicate that the dataset was sufficiently stable for the subsequent stages of the analysis and that no construct displayed a level of nonnormality serious enough to raise concern at this stage of the study (Hair et al., 2019).

4.6. Construct Reliability and Validity

This section assesses the reliability and convergent validity of the reflective constructs included in the study. In PLS-SEM, the evaluation of the measurement model begins with internal consistency reliability and convergent validity in order to determine whether the indicators of each construct consistently measure the same underlying concept and whether the construct explains a sufficient proportion of variance in its indicators. The present assessment relies on four widely used criteria, namely Cronbach's alpha, rho_A, composite reliability, and average variance extracted (AVE). In methodological terms, values of 0.70 or higher are generally considered acceptable for Cronbach's alpha, rho_A, and composite reliability, while AVE values of 0.50 or above indicate adequate convergent validity (Hair et al., 2022; Dijkstra & Henseler, 2015).

Table 37: Construct Reliability and Validity

Latent Variables	Cronbach's Alpha	rho_A	Composite Reliability	AVE
BIM	0.962	0.962	0.968	0.814
CC	0.942	0.942	0.956	0.813
ECP	0.922	0.968	0.943	0.807
EMP	0.924	0.936	0.946	0.813
ENP	0.789	0.799	0.855	0.542
OOR	0.924	1.008	0.942	0.803
OTMS	0.966	0.98	0.971	0.807
TCO	0.941	0.976	0.951	0.735
TCOM	0.932	1.008	0.95	0.826
TRA	0.941	0.952	0.955	0.809

Source. Developed by the researcher based on the survey data.

Table 37 shows that all constructs achieved acceptable to very strong levels of internal consistency reliability. Cronbach's alpha values ranged from 0.789 for ENP to 0.966 for OTMS, and all values exceeded the commonly accepted threshold of 0.70. Similarly, composite reliability values ranged from 0.855 for ENP to 0.971 for OTMS, again remaining above the recommended minimum. These results indicate that the indicators within each construct were sufficiently consistent in measuring the same latent concept. The rho_A values also exceeded the threshold level across all constructs, which further supports reliability. However, two constructs, OOR and TCOM, produced rho_A values slightly above 1.00. This point should be interpreted cautiously, because SmartPLS notes that rho_A may occasionally generate inadmissible solutions under certain conditions, even though it remains a consistent reliability estimator in PLS-SEM. In the present case, the slightly elevated rho_A values do not overturn the overall conclusion of acceptable construct reliability, especially because

Cronbach's alpha and composite reliability for the same constructs remain comfortably within acceptable ranges (Dijkstra & Henseler, 2015; Hair et al., 2022).

With regard to convergent validity, all AVE values exceeded the threshold of 0.50, ranging from 0.542 for ENP to 0.826 for TCOM. This indicates that each construct explained more than half of the variance in its indicators, which is the basic requirement for satisfactory convergent validity. In substantive terms, the AVE results suggest that the indicators of BIM, CC, ECP, EMP, ENP, OOR, OTMS, TCO, TCOM, and TRA converged adequately on their intended latent variables. Although ENP recorded the lowest AVE value among the constructs, its value of 0.542 still remained above the minimum acceptable level and therefore does not raise a convergent validity problem. Overall, the results reported in Table 37 provide strong evidence that the measurement scales used in the study were both internally reliable and convergently valid, which supports proceeding to the next stage of discriminant validity assessment (Fornell & Larcker, 1981; Hair et al., 2022).

4.7. Fornell-Larcker Criterion

This subsection evaluates discriminant validity using the Fornell-Larcker criterion. In reflective measurement models, discriminant validity refers to the extent to which each construct is empirically distinct from the other constructs in the model. According to the Fornell-Larcker approach, discriminant validity is supported when the square root of the AVE for each construct is greater than its correlations with all other constructs. Although this criterion remains widely reported in PLS-SEM studies, more recent methodological guidance notes that it may not always detect discriminant validity problems reliably, which is why it should be interpreted together with cross-loadings and HTMT results rather than in isolation.

Table 38: Fornell-Larcker Criterion

Latent Variables	BIM	CC	ECP	EMP	ENP	OOR	OTMS	TCO	TCOM	TRA
BIM	0.902									
CC	0.636	0.901								
ECP	0.087	-0.053	0.898							
EMP	0.169	0.005	-0.073	0.902						
ENP	0.519	0.033	-0.001	0.010	0.736					
OOR	0.112	0.002	0.034	0.035	0.059	0.896				
OTMS	0.122	0.068	-0.008	-0.029	-0.065	-0.036	0.898			
TCO	0.116	-0.022	0.098	-0.029	0.017	-0.026	-0.008	0.857		
TCOM	0.057	-0.016	-0.059	0.053	-0.055	-0.066	-0.002	-0.031	0.909	
TRA	0.249	0.089	-0.044	0.086	0.031	-0.029	0.005	0.040	-0.009	0.899

Source. Developed by the researcher based on the survey data.

Table 38 shows that the square root of the AVE for each construct was higher than its correlations with all other constructs. For example, the square root of the AVE for BIM was 0.902, which exceeded its highest correlation with another construct, namely CC at 0.636. Similarly, the square root of the AVE for CC was 0.901, which was also greater than its highest correlation, again with BIM at 0.636. The same pattern can be observed across the remaining constructs, including ECP, EMP, ENP, OOR, OTMS, TCO, TCOM, and TRA. These results indicate that each construct shared more variance with its own indicators than with any other construct in the model, which supports discriminant validity under the Fornell-Larcker criterion.

4.8. Cross-Loadings of the Study Variables

This subsection evaluates discriminant validity by examining the cross-loadings of the indicators. The basic logic of this assessment is that each indicator should load more strongly on its own construct than on any other construct in the model. Cross-loadings therefore provide an item-level view of construct distinctiveness and help determine whether the observed indicators are aligned with their intended latent variables. As with the Fornell-Larcker criterion, cross-loadings remain a recognized procedure in PLS-SEM, but they should be interpreted alongside HTMT because they may not detect all discriminant validity problems on their own.

Table 39: Cross-Loadings of the Study Variables

Latent Variables	BIM	CC	ECP	EMP	ENP	OOR	OTMS	TCOM	TCO	TRA
BIM_item1	0.907	0.556	0.071	0.165	0.464	0.097	0.077	0.042	0.127	0.225
BIM_item2	0.902	0.603	0.113	0.149	0.435	0.063	0.129	0.062	0.085	0.198
BIM_item3	0.904	0.584	0.069	0.129	0.472	0.136	0.081	0.043	0.100	0.217
BIM_item4	0.890	0.541	0.039	0.156	0.492	0.110	0.110	0.086	0.066	0.204
BIM_item5	0.906	0.574	0.117	0.156	0.481	0.116	0.101	0.048	0.094	0.230
BIM_item6	0.897	0.559	0.079	0.158	0.448	0.076	0.179	0.034	0.134	0.254
BIM_item7	0.909	0.598	0.061	0.156	0.482	0.108	0.091	0.045	0.124	0.243
CC_item1	0.574	0.900	-0.021	-0.009	0.028	0.032	0.066	-0.017	-0.023	0.081
CC_item2	0.573	0.902	-0.048	0.004	0.031	0.015	0.103	-0.054	-0.003	0.105
CC_item3	0.582	0.904	-0.073	-0.003	0.037	-0.039	0.053	0.010	-0.036	0.067
CC_item4	0.562	0.905	-0.047	-0.031	0.047	0.005	0.032	0.002	-0.030	0.070
CC_item5	0.574	0.896	-0.052	0.061	0.008	-0.003	0.050	-0.014	-0.008	0.076
ECP_item1	0.045	-0.091	0.886	-0.122	-0.024	0.062	0.013	-0.067	0.138	-0.067
ECP_item2	0.083	-0.046	0.912	-0.084	0.025	0.028	-0.014	-0.043	0.059	-0.007
ECP_item3	0.097	-0.031	0.917	-0.017	0.008	0.022	-0.002	-0.054	0.088	-0.082
ECP_item4	0.068	-0.046	0.877	-0.076	-0.030	0.023	-0.019	-0.055	0.093	-0.003
EMP_item1	0.164	-0.028	-0.065	0.920	0.024	0.066	-0.021	0.058	-0.020	0.093
EMP_item2	0.172	0.023	-0.082	0.908	0.021	0.058	-0.050	0.060	-0.053	0.065
EMP_item3	0.142	0.016	-0.037	0.889	-0.008	-0.017	-0.036	0.013	-0.018	0.097
EMP_item4	0.126	0.011	-0.079	0.889	-0.005	0.006	0.013	0.059	-0.008	0.054
ENP_item1	0.304	-0.054	-0.008	0.017	0.702	0.025	-0.053	-0.041	-0.037	-0.006
ENP_item2	0.433	0.091	0.041	0.024	0.763	-0.033	-0.021	-0.047	0.051	0.030
ENP_item3	0.350	-0.019	-0.017	0.028	0.741	0.081	-0.095	-0.009	-0.031	0.053
ENP_item4	0.348	-0.001	-0.036	-0.020	0.693	0.036	-0.063	-0.121	0.043	0.011
ENP_item5	0.443	0.069	0.004	-0.009	0.778	0.108	-0.024	0.005	0.018	0.022
OOR_item1	0.029	-0.026	0.055	0.011	-0.015	0.850	-0.056	-0.092	-0.016	-0.033
OOR_item2	0.099	-0.010	0.030	-0.003	0.083	0.903	-0.045	-0.040	-0.033	-0.043
OOR_item3	0.083	-0.039	0.054	0.027	0.045	0.902	-0.023	-0.078	-0.032	-0.024
OOR_item4	0.131	0.042	0.011	0.066	0.053	0.928	-0.023	-0.057	-0.012	-0.014
OTMS_item1	0.110	0.049	0.013	-0.024	-0.069	-0.037	0.904	0.036	-0.026	0.033
OTMS_item2	0.124	0.082	-0.037	-0.023	-0.053	-0.009	0.904	-0.034	0.007	0.022
OTMS_item3	0.110	0.032	0.017	-0.023	-0.050	0.012	0.893	-0.018	0.026	-0.004
OTMS_item4	0.088	0.081	-0.042	-0.049	-0.075	-0.040	0.894	0.026	-0.025	-0.009
OTMS_item5	0.138	0.096	-0.008	-0.004	-0.047	-0.053	0.900	-0.005	-0.007	-0.008
OTMS_item6	0.045	0.042	0.000	-0.035	-0.101	-0.073	0.893	0.023	-0.042	-0.011
OTMS_item7	0.111	0.035	0.019	-0.026	-0.043	-0.031	0.902	-0.032	0.011	0.010
OTMS_item8	0.094	0.048	-0.019	-0.040	-0.066	-0.050	0.897	0.014	-0.028	-0.008
TCOM_item1	0.041	-0.030	-0.084	0.043	-0.022	-0.102	-0.013	0.885	-0.033	-0.018
TCOM_item2	0.052	-0.004	-0.052	0.041	-0.051	-0.031	-0.003	0.923	-0.033	-0.010
TCOM_item3	0.029	-0.007	-0.052	0.036	-0.093	-0.045	-0.008	0.893	-0.048	-0.046
TCOM_item4	0.068	-0.017	-0.038	0.063	-0.047	-0.064	0.007	0.933	-0.014	0.014
TCO_item1	0.064	-0.036	0.028	-0.029	-0.020	-0.050	0.004	-0.005	0.848	0.037
TCO_item2	0.061	-0.055	0.080	-0.018	0.032	-0.042	-0.004	-0.053	0.841	0.044
TCO_item3	0.069	-0.064	0.057	0.033	0.049	-0.013	0.002	-0.044	0.848	0.002
TCO_item4	0.103	-0.016	0.081	-0.046	0.006	-0.026	-0.049	-0.020	0.867	0.074
TCO_item5	0.099	-0.009	0.141	-0.050	0.026	-0.047	0.010	0.022	0.861	0.015
TCO_item6	0.140	0.025	0.111	-0.022	-0.012	0.000	-0.028	-0.017	0.872	0.021
TCO_item7	0.106	-0.030	0.056	-0.027	0.034	-0.001	0.036	-0.080	0.863	0.045
TRA_item1	0.160	0.034	-0.022	0.056	-0.013	-0.056	0.004	-0.016	0.031	0.887
TRA_item2	0.252	0.108	-0.056	0.055	0.056	0.010	0.034	0.004	0.007	0.903
TRA_item3	0.219	0.068	-0.041	0.095	0.005	-0.015	-0.021	0.011	0.017	0.902
TRA_item4	0.244	0.089	-0.031	0.113	0.051	-0.057	0.013	-0.052	0.064	0.908
TRA_item5	0.221	0.083	-0.043	0.061	0.023	-0.025	-0.012	0.011	0.060	0.897

Source. Developed by the researcher based on the survey data.

Table 39 shows that each indicator loaded highest on its intended construct. The BIM indicators, for example, loaded between 0.890 and 0.909 on BIM, while their loadings on the remaining constructs were consistently lower. The same pattern was observed for CC, ECP, EMP, ENP, OOR, OTMS, TCOM, TCO, and TRA. This indicates that the indicators were more strongly associated with their own latent variables than with alternative constructs, which supports discriminant validity at the indicator level.

At the same time, some indicators showed moderate secondary loadings on theoretically related constructs, especially between BIM and CC and between BIM and ENP. For instance, several BIM items showed secondary loadings above 0.50 on CC, and some ENP items showed moderate secondary loadings on BIM. These patterns are not unexpected given the conceptual relatedness of the constructs, but the primary loading of each item still remained clearly higher on its designated construct than on any competing construct. Accordingly, the cross-loading results provide additional support for discriminant validity, while also justifying the need for the more stringent HTMT assessment that follows.

4.9. Heterotrait-Monotrait Ratio of Correlations (HTMT)

This subsection assesses discriminant validity using the HTMT ratio. The HTMT criterion is now widely regarded as a more sensitive and rigorous method for detecting discriminant validity problems in PLS-SEM than the Fornell-Larcker criterion or cross-loadings alone. Current guidance generally interprets HTMT values below 0.85 as conservative evidence of discriminant validity and values below 0.90 as acceptable under a more liberal standard, especially when constructs are conceptually related. For this reason, HTMT is often treated as the most important confirmatory check of construct distinctiveness in reflective models.

Table 40: Heterotrait-Monotrait Ratio of Correlations (HTMT)

Latent Variables	BIM	CC	ECP	EMP	ENP	OOR	OTMS	TCO	TCOM	TRA
BIM										
CC	0.668									
ECP	0.086	0.064								
EMP	0.177	0.036	0.095							
ENP	0.585	0.083	0.050	0.036						
OOR	0.102	0.039	0.050	0.049	0.088					
OTMS	0.119	0.069	0.025	0.038	0.086	0.052				
TCO	0.112	0.043	0.106	0.039	0.060	0.036	0.036			
TCOM	0.057	0.026	0.068	0.059	0.084	0.080	0.027	0.051		
TRA	0.256	0.090	0.051	0.090	0.053	0.042	0.024	0.050	0.034	

Source. Developed by the researcher based on the survey data.

Table 40 indicates that all HTMT values were well below the threshold of 0.90, and they also remained below the more conservative threshold of 0.85. The highest HTMT value was observed between BIM and CC at 0.668, followed by BIM and ENP at 0.585. Although these values indicate that the constructs are meaningfully related, they remain comfortably below the recommended cutoffs and therefore do not suggest

a discriminant validity problem. All remaining HTMT values were substantially lower, many of them far below 0.20, which provides strong additional evidence that the constructs were empirically distinct from one another.

4.10. Collinearity Statistics Inner VIF

This subsection examines collinearity among the predictor constructs included in the structural model. Assessing collinearity is necessary before interpreting the path coefficients because high collinearity among predictors may distort regression estimates and reduce the clarity of the model's results. In the present study, Inner VIF values were used to determine whether the predictor constructs of BIM adoption, including the interaction term $ENP \times CC$, showed any problematic overlap that could affect hypothesis testing.

Table 41: Inner VIF Values for the Predictors of BIM

Predictor of BIM	Inner VIF
CC	1.018
ECP	1.023
EMP	1.022
ENP	1.013
$ENP \times CC$	1.013
OOR	1.014
OTMS	1.011
TCO	1.02
TCOM	1.015
TRA	1.023

Source. Developed by the researcher based on the survey data.

Table 41 shows that all Inner VIF values ranged from 1.011 to 1.023, which indicates that collinearity was not a concern in the structural model. All values were far below the commonly accepted threshold levels, confirming that the predictor constructs did not exhibit problematic overlap. This means that the independent variables, including the interaction term $ENP \times CC$, could be retained in the model without threatening the stability or interpretability of the path estimates. Therefore, the structural model was considered suitable for path analysis and hypothesis testing.

4.11. Paths of the Study Relationships

This subsection presents the results of the structural model assessment. For clarity of presentation, the results are divided into two parts. The first part reports the direct relationships between the technological, organizational, and environmental constructs and BIM adoption. The second part reports the moderating relationship between Corporate Culture on the relationship between Normative Pressures and BIM

adoption. This structure is more consistent with the final model of the study because CC is treated only as a moderator and not as a direct predictor of BIM adoption.

4.11.1. Direct Relationships with BIM Adoption

This subsection reports the direct relationships between TCO, TRA, TCOM, OTMS, OOR, EMP, ECP, and ENP and Building Information Modeling adoption as an organizational-level construct reflecting the formal and practical uptake of BIM within the firm, rather than mere awareness or isolated technical familiarity alone, as discussed by Succar (2009), Ahmed and Kassem (2018), and Ahuja et al. (2016). The path coefficients are therefore interpreted in relation to the extent to which these antecedents are associated with stronger organizational commitment to BIM, wider organizational support for BIM use, greater routinization of BIM-related practice, and stronger continuity of BIM adoption within the firm, consistent with the study's revised operationalization of the dependent variable and with the distinction between adoption, implementation, and use in the BIM literature, as noted by Succar (2009) and Ahmed and Kassem (2018).

Table 42: Direct Relationships with BIM Adoption

Relationships	Standardized Regression Coefficient	Standard Deviation	T Statistics	P Values
TCO → BIM	0.116	0.031	3.786	0.0
TRA → BIM	0.174	0.029	6.042	0.0
TCOM → BIM	0.107	0.035	3.044	0.002
OTMS → BIM	0.121	0.025	4.882	0.0
OOR → BIM	0.089	0.028	3.145	0.002
EMP → BIM	0.15	0.024	6.232	0.0
ECP → BIM	0.132	0.032	4.086	0.0
ENP → BIM	0.498	0.034	14.527	0.0

Source. Developed by the researcher based on the survey data.

Table 42 shows that all direct relationships in the structural model were positive and statistically significant. Among the direct predictors, ENP had the strongest effect on BIM adoption, with a standardized regression coefficient of 0.498. This indicates that Normative Pressures represented the most influential direct predictor of BIM adoption in the model. TRA also showed a relatively strong positive effect, with a coefficient of 0.174, followed by EMP with 0.150, ECP with 0.132, OTMS with 0.121, TCO with 0.116, and TCOM with 0.107. OOR recorded the smallest direct coefficient, 0.089, but the relationship remained statistically significant. Overall, these findings indicate that

BIM adoption in the Libyan construction sector was positively influenced by all the direct antecedents included in the final model.

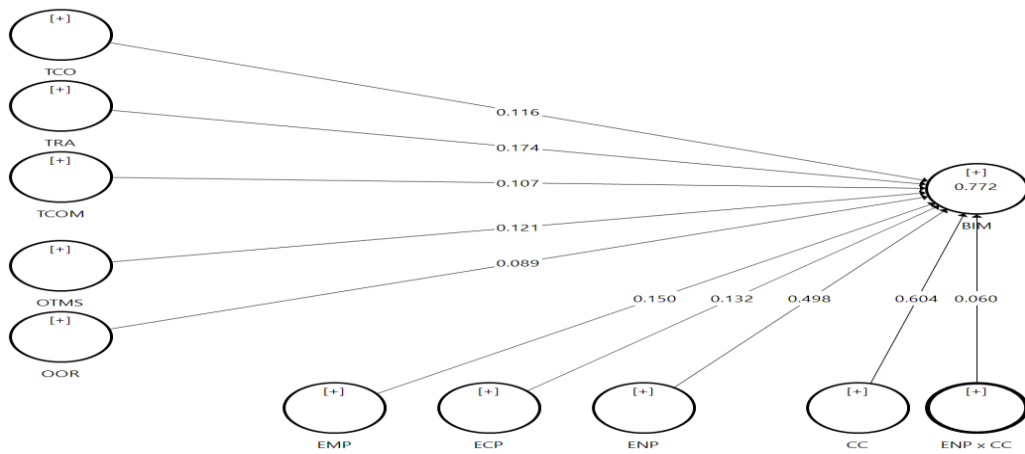


Figure 7. Direct Relationships with BIM Adoption

4.11.2. The Moderating Role of Corporate Culture

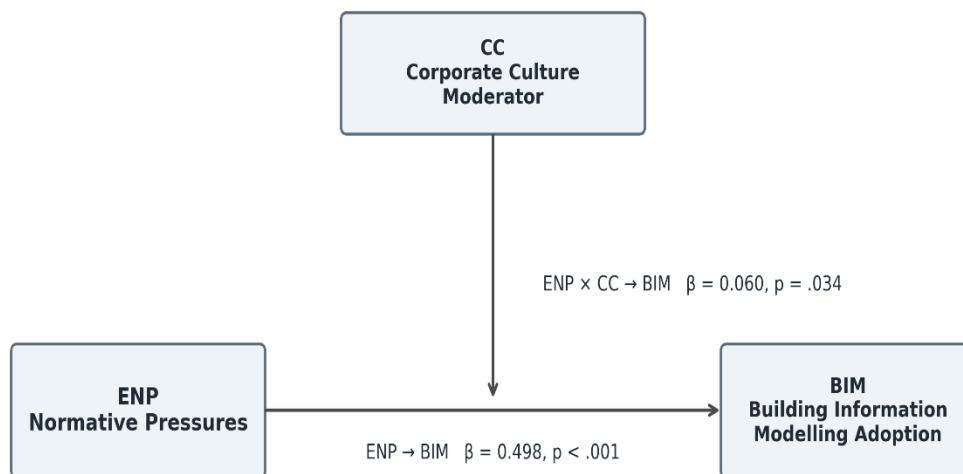
The moderating analysis examined whether Corporate Culture changes the strength of the relationship between Normative Pressures and BIM adoption. In the present study, Corporate Culture refers to a general internal cultural condition characterized by openness to new ways of working, support for learning and continuous improvement, collaboration across functions, receptiveness to change initiatives, and senior-management values supportive of innovation and organizational development, rather than to a BIM-specific supportive climate alone (Alankarage et al., 2023; Dai et al., 2018; Behl et al., 2022). The positive and statistically significant interaction effect therefore indicates that the influence of normative pressures on BIM adoption became stronger when the organization's internal culture was more supportive of learning, collaboration, innovation, and change-oriented development. This interpretation is conceptually important because it shows that professionally endorsed external expectations are more likely to be translated into formal and continuing BIM adoption when the internal cultural environment of the firm is receptive to change and organizational development, which is consistent with the moderating logic adopted in the conceptual model of the study (Alankarage et al., 2023; Behl et al., 2022; Dai et al., 2018; Tavallaei et al., 2022).

Table 43: Moderating relationship between Corporate Culture on the Relationship Between ENP and BIM Adoption

Moderating Relationship	Standardized Regression Coefficient	Standard Deviation	T Statistics	P Values
ENP × CC → BIM	0.06	0.028	2.124	0.034

Source. Developed by the researcher based on the survey data.

Table 43 shows that the interaction term ENP × CC → BIM was positive and statistically significant, with a standardized regression coefficient of 0.060, a t value of 2.124, and a p value of 0.034. This result indicates that CC significantly moderated the relationship between ENP and BIM adoption. The positive sign of the interaction suggests that the relationship between Normative Pressures on BIM adoption became stronger when Corporate Culture was more supportive. Although the magnitude of the moderating effect was smaller than the main direct relationship between ENP, it remained statistically meaningful and supports the position that Corporate Culture plays a conditioning role in how organizations respond to normative pressures related to BIM adoption.



CC is modeled only as a moderator, not as a direct predictor of BIM.

Figure 8. Moderating relationship between Corporate Culture on the Relationship Between ENP and BIM Adoption

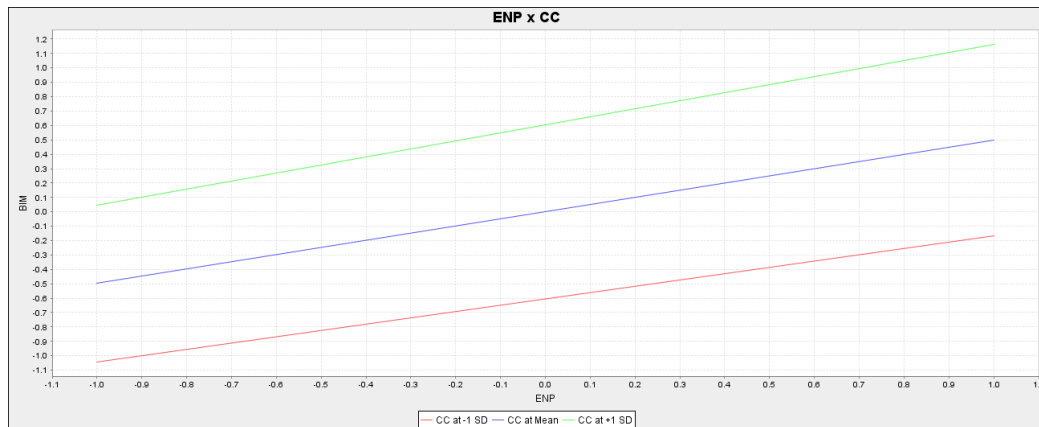


Figure 9. The Moderator relationship between CC

4.12. Explanatory Power and Model Fit

This subsection presents the explanatory power and model fit of the structural model. In PLS-SEM, the coefficient of determination, R Square, is used to assess how much variance in the dependent variable is explained by its predictor constructs, while the adjusted R Square provides a slightly more conservative estimate by taking model complexity into account. In addition, SmartPLS reports several model fit indices, including SRMR, NFI, d_ULS, d_G, and Chi-Square. Among these indices, SRMR and NFI are commonly used as approximate fit measures, with values such as SRMR below 0.08 and NFI above 0.90 typically interpreted as indicating acceptable model fit.

Table 45: Explanatory Power and Model Fit of the Study Model

Model	R Square	R Square Adjusted	SRMR	d_ULS	d_G	Chi-Square	NFI
BIM	0.772	0.766	0.034	1.693	0.843	1907.685	0.9

Source. Developed by the researcher based on the survey data.

Table 45 shows that the model explained a substantial proportion of the variance in BIM adoption. The R Square value of 0.772 indicates that 77.2 percent of the variance in BIM was explained by the predictor constructs included in the model, while the adjusted R Square value of 0.766 shows that the explanatory power remained strong even after taking model complexity into account. This result suggests that the structural model had high predictive strength with respect to BIM adoption in the Libyan construction sector. The SRMR value was 0.034, which is well below the commonly referenced threshold of 0.08, indicating good approximate model fit. The NFI value was 0.900, which meets the commonly used benchmark for acceptable fit in SmartPLS-based reporting.

Table 45 also reports d_{ULS} , d_G , and Chi-Square as supplementary model fit statistics generated by SmartPLS. These values are useful for reporting the overall model estimation results, but the main interpretation in the present study is based on the stronger explanatory power reflected in R Square and adjusted R Square, together with the acceptable approximate fit indicated by SRMR and NFI. Overall, the results suggest that the proposed model achieved satisfactory explanatory power and acceptable model fit, which supports the adequacy of the structural model for interpreting the relationships affecting BIM adoption.

4.13. Summary of Hypotheses Testing

This subsection summarizes the final hypothesis-testing results of the study in a concise form. The purpose of this Table 44 is to present an integrated view of the empirical status of all proposed hypotheses after the structural model assessment. Presenting the hypothesis results in this way improves clarity and makes it easier to see whether each proposed relationship was supported by the empirical evidence. In line with the final model of the study, Table 44 includes the eight direct hypotheses related to BIM adoption and the one moderating hypothesis related to the interaction between ENP and CC.

Table 44: Summary of Hypotheses Testing

Hypothesis	Relationship	Standardized Regression Coefficient	T Statistics	P Value	Decision
H1	TCO → BIM	0.116	3.786	0.0	Supported
H2	TRA → BIM	0.174	6.042	0.0	Supported
H3	TCOM → BIM	0.107	3.044	0.002	Supported
H4	OTMS → BIM	0.121	4.882	0.0	Supported
H5	OOR → BIM	0.089	3.145	0.002	Supported
H6	EMP → BIM	0.15	6.232	0.0	Supported
H7	ECP → BIM	0.132	4.086	0.0	Supported
H8	ENP → BIM	0.498	14.527	0.0	Supported
H9	ENP × CC → BIM	0.06	2.124	0.034	Supported

Source. Developed by the researcher based on the survey data.

Table 44 shows that all hypotheses proposed in the final model were supported by the empirical results. All eight direct hypotheses produced positive and statistically significant relationships with BIM adoption, which indicates that technological, organizational, and environmental factors all contributed meaningfully to explaining BIM adoption in the Libyan construction sector. Among these direct relationships, ENP had the strongest coefficient, followed by TRA and EMP, while OOR recorded the smallest coefficient, although it remained statistically significant. The moderating

hypothesis was also supported, as the interaction term $ENP \times CC$ showed a positive and significant relationship with BIM adoption. This result indicates that Corporate Culture strengthened the relationship between Normative Pressures and BIM adoption. Overall, the hypothesis-testing results provide strong empirical support for the final structure of the study model and indicate that BIM adoption in the Libyan construction sector was associated with a combination of direct antecedents and a focused moderating relationship.

4.14. Summary

This chapter presented the empirical findings of the study on the predictor of Building Information Modeling adoption in the Libyan construction sector. The chapter began by profiling the respondents and showed that the sample of 389 participants reflected a professionally relevant group drawn from different age categories, educational levels, job positions, organizational types, and levels of BIM familiarity. This provided a credible empirical basis for evaluating the study variables and interpreting the subsequent statistical results. The descriptive statistics showed that the major constructs of the study were generally perceived at moderate to moderately positive levels. The mean values indicated that respondents recognized the relevance of TCO, TRA, TCOM, OTMS, OOR, EMP, ECP, ENP, and CC to BIM adoption, although the strength of responses varied across constructs and items. BIM adoption itself was also perceived at a moderate level, which suggests that BIM had not yet reached a fully established stage of organizational integration in the Libyan construction sector. The preliminary statistical assessment further showed that the data were suitable for multivariate analysis. The correlation analysis indicated that BIM adoption was positively associated with all main constructs, although the strength of these relationships differed. The strongest bivariate associations were found with CC and ENP, while the remaining constructs showed weaker but still positive relationships with BIM. The skewness and kurtosis values also indicated that the distributions of the study variables were approximately normal and did not present serious distributional problems. The chapter then evaluated the measurement model. The results showed that all constructs achieved acceptable to strong levels of internal consistency reliability, as confirmed by Cronbach's alpha, rho_A, and composite reliability. Convergent validity was also established, since all AVE values exceeded the acceptable threshold. In addition, discriminant validity was supported by the Fornell-Larcker criterion, the cross-

loadings, and the HTMT results, which together confirmed that the constructs were empirically distinct from one another. The collinearity assessment further showed that all Inner VIF values were very low, indicating that collinearity was not a concern in the structural model. The structural model assessment showed that all direct relationships included in the final model were positive and statistically significant. Specifically, TCO, TRA, TCOM, OTMS, OOR, EMP, ECP, and ENP all had significant positive effects on BIM adoption. Among these predictors, ENP emerged as the strongest direct predictor of BIM adoption, followed by TRA and EMP. The results therefore confirmed that BIM adoption in the Libyan construction sector was associated with a combination of technological, organizational, and environmental influences rather than by a single explanatory factor. The moderation analysis also supported the final theoretical position of the study. The interaction term $ENP \times CC$ had a positive and statistically significant effect on BIM adoption, which indicates that Corporate Culture strengthened the relationship between Normative Pressures on BIM adoption. This means that the influence of normative expectations, professional standards, and accepted industry practices became stronger when the organizational culture was more supportive. In this way, the results confirmed the focused moderating role assigned to CC in the final model. Finally, the model demonstrated strong explanatory power and acceptable fit. The R Square value showed that a substantial proportion of the variance in BIM adoption was explained by the predictors included in the model, while the SRMR and NFI values indicated satisfactory model fit. Overall, this chapter provided strong empirical support for the final model of the study and established a clear statistical foundation for the discussion, implications, and conclusions presented in the next chapter.

5. CHAPTER FIVE: DISCUSSION AND CONCLUSION

5.1. Introduction

This chapter discusses the empirical findings of the study in relation to the research objectives, the theoretical foundations of the model, and the wider literature on Building Information Modeling adoption in construction organizations. The chapter is structured to interpret the statistically significant relationships identified in the structural model, clarify their theoretical and practical meaning, and situate the results within the specific context of the Libyan construction sector. In doing so, the chapter does not treat the findings as evidence of strict temporal causality. Rather, it interprets them as meaningful empirical relationships identified within the cross-sectional survey design and the PLS-SEM analytical framework adopted in the study, which is methodologically more consistent with the design of the research and the nature of the collected data.

The discussion begins with a recapitulation of the study and then proceeds to the interpretation of the direct relationships between the technological, organizational, and environmental predictors and BIM adoption. It then addresses the moderating role of Corporate Culture in the relationship between Normative Pressures and BIM adoption before moving to the theoretical implications, practical implications, limitations, recommendations for future research, and overall conclusion of the study. This structure is appropriate because the study was designed to explain BIM adoption at the organizational level through an integrated TOE-based model enriched by Institutional Theory and a focused cultural moderation effect, rather than through a single-factor explanation of digital uptake.

Within the present study, BIM adoption is interpreted as an organizational innovation outcome reflecting formal and continuing uptake of BIM-related practice within firms in the Libyan construction sector. On this basis, the findings reported in this chapter are discussed in terms of the extent to which technological perceptions, organizational support conditions, and external institutional pressures were statistically associated with stronger organizational BIM adoption, while Corporate Culture functioned as a focused internal condition shaping the strength of the relationship between Normative Pressures and BIM adoption. In this sense, the chapter aims to provide a balanced and context-sensitive interpretation of the results, one that is

theoretically grounded, empirically disciplined, and methodologically aligned with the actual design of the study.

5.2. Recapitulation of the Study

The present study was designed to explain Building Information Modeling adoption in the Libyan construction sector through a model that integrated technological, organizational, and environmental predictors within a TOE-based structure enriched by a focused cultural moderation effect (Baker, 2012; Ahmed & Kassem, 2018). It responded to the observation that BIM has become globally important in construction practice, yet its adoption in Libya remains uneven and insufficiently embedded in routine organizational processes (Chowdhury et al., 2024; Charef et al., 2019). The direct predictors in the model were TCO, TRA, TCOM, OTMS, OOR, EMP, ECP, and ENP, while Corporate Culture was positioned solely as a moderator of the relationship between ENP and BIM adoption (Tavallaei et al., 2022; Alankarage et al., 2023). The study adopted a quantitative cross-sectional design and analyzed 389 valid responses from professionals working in the Libyan construction sector using SPSS and SmartPLS procedures appropriate for structural model estimation and moderation testing (Hair et al., 2022; Magalhães et al., 2023). The results showed that all direct paths to BIM adoption were positive and statistically significant, and that ENP was the strongest direct predictor, followed by TRA and EMP, while the $ENP \times CC$ interaction was also positive and significant (Tavallaei et al., 2022; Wang et al., 2024). These findings indicate that BIM adoption in Libya is statistically associated with a combination of legitimacy pressures, perceived technological value, organizational support, readiness conditions, and cultural receptiveness rather than with a single isolated predictor (Baker, 2012; Chowdhury et al., 2024).

5.3. Discussion of the Direct Relationships with BIM Adoption

5.3.1. Discussion of the ENP and BIM Relationship

The results confirmed that normative pressures exerted the strongest direct relationship with BIM adoption in the structural model, with a path coefficient of $\beta = 0.498$, a t-statistic of 14.527, and a p-value of 0.000, which means that organizational BIM uptake in the Libyan construction sector was associated most strongly with professionally endorsed expectations, accepted industry practices, and field-level legitimacy pressures (Tavallaei et al., 2022; DiMaggio & Powell, 1983). This result is

theoretically important because institutional theory argues that organizations adopt practices not only because those practices are efficient, but also because they are increasingly regarded as appropriate, credible, and professionally legitimate within the organizational field (DiMaggio & Powell, 1983; Baker, 2012). In the BIM context, such pressure is expressed through professional discourse, educational influence, technical guidance, and the wider expectation that BIM represents contemporary and competent construction practice (Chowdhury et al., 2024; Wang et al., 2024). The strength of this relationship suggests that organizations in Libya are responding to BIM partly as a legitimacy-bearing organizational practice rather than as a technical tool only, which is consistent with evidence showing that normative pressure can be the most influential institutional driver of BIM uptake in AEC organizations (Tavallaei et al., 2022; Charef et al., 2019). Practically, the result implies that stronger professional normalization through associations, standards, curricula, and industry guidance may be one of the most effective ways to accelerate the formal and continuing uptake of BIM in Libya (Chowdhury et al., 2024; Tavallaei et al., 2022).

5.3.2. Discussion of the TRA and BIM Relationship

The empirical findings also showed that relative advantage had a positive and statistically significant relationship with BIM adoption, with $\beta = 0.174$, $t = 6.042$, and $p = 0.000$, which indicates that stronger perceptions of BIM's usefulness and practical superiority were associated with stronger organizational BIM uptake in the Libyan construction sector (Murguia et al., 2023; Wang et al., 2024). This finding is theoretically consistent with innovation-adoption logic, which holds that organizations are more likely to move toward formal adoption and continued use when they perceive a new system as offering clear improvement over existing routines, methods, and tools (Baker, 2012; Ahmed & Kassem, 2018). In the case of BIM, such advantages are typically linked to improved coordination, stronger visualization, better information integration, and more effective project management processes (Chowdhury et al., 2024; Murguia et al., 2023). The significance of TRA in the present study therefore suggests that Libyan construction organizations are more likely to institutionalize BIM when they believe that it offers meaningful organizational value beyond traditional methods. Practically, this means that firms, professional bodies, and policymakers should not promote BIM only as a digital trend, but should also demonstrate its concrete

organizational benefits in relation to coordination quality, information flow, and project delivery performance (Murguia et al., 2023; Wang et al., 2024).

5.3.3. Discussion of the EMP and BIM Relationship

The study also found that mimetic pressures had a positive and statistically significant relationship with BIM adoption, with $\beta = 0.150$, $t = 6.232$, and $p = 0.000$, indicating that organizational BIM uptake in Libya was positively associated with the tendency of firms to observe and imitate other organizations perceived as successful, advanced, or strategically legitimate (DiMaggio & Powell, 1983; Cao et al., 2014). This result is theoretically meaningful because mimetic pressure becomes especially influential when organizations operate under uncertainty and seek cues from visible peers, competitors, consultants, and project partners regarding appropriate strategic action (DiMaggio & Powell, 1983; Tavallaei et al., 2022). In the BIM context, this means that organizations may move toward BIM not only because of internal evaluation, but also because BIM use by leading firms signals modernity, competitiveness, and professional relevance in the field (Salem et al., 2025; Saka et al., 2024). The significance of EMP in the present study suggests that BIM diffusion in Libya is partly driven by inter-organizational observation and imitation. Practically, this implies that visible BIM success stories, demonstration projects, and peer benchmarking may play an important role in accelerating wider organizational BIM uptake across the Libyan construction sector (Cao et al., 2014; Tavallaei et al., 2022).

5.3.4. Discussion of the ECP and BIM Relationship

The findings further showed that coercive pressures had a positive and statistically significant relationship with BIM adoption, with $\beta = 0.132$, $t = 4.086$, and $p = 0.000$, which indicates that stronger formal or dependency-based external demands were associated with greater organizational BIM uptake in Libyan construction firms (DiMaggio & Powell, 1983; Cao et al., 2014). This result is consistent with institutional theory, which argues that organizations often respond to requirements, expectations, and constraints imposed by powerful external actors such as clients, regulators, public authorities, or dominant project partners (DiMaggio & Powell, 1983). In the BIM context, coercive pressure may arise through procurement expectations, major-client requirements, regulatory guidance, or contractual pressures that alter the practical cost of non-adoption (Tavallaei et al., 2022; Salem et al., 2025). The present finding therefore

suggests that BIM uptake in Libya is not only a matter of internal preference or professional culture, but is also influenced by formal expectations and structural dependency relationships in the external environment. Practically, this implies that stronger government backing, public procurement signals, and major-client encouragement could contribute meaningfully to widening the formal uptake of BIM within the sector (Cao et al., 2014; Salem et al., 2025).

5.3.5. Discussion of the OTMS and BIM Relationship

The study also confirmed that top management support had a positive and statistically significant relationship with BIM adoption, with $\beta = 0.121$, $t = 4.882$, and $p = 0.000$, indicating that stronger leadership commitment was associated with stronger organizational BIM uptake in the Libyan construction sector (Tavallaei et al., 2022; Villena-Manzanares et al., 2021). This result is theoretically important because BIM is not adopted and sustained through technical availability alone. It also depends on whether senior decision makers authorize change, allocate resources, legitimize digital transformation, and provide visible institutional backing for new practices within the firm (Ahmed & Kassem, 2018; Tavallaei et al., 2022). In this sense, the result suggests that BIM is more likely to move from intention into routinized organizational practice when top managers treat it as a strategic priority rather than as an optional technical experiment. Practically, the finding implies that firms seeking stronger BIM uptake should strengthen executive commitment, managerial sponsorship, and visible internal leadership for BIM-related change, because organizational continuity and formal support remain essential to the adoption process (Villena-Manzanares et al., 2021; Tavallaei et al., 2022).

5.3.6. Discussion of the TCO and BIM Relationship

The empirical results showed that TCO had a positive and statistically significant relationship with BIM adoption, with $\beta = 0.116$, $t = 3.786$, and $p = 0.000$. This relationship should be interpreted in light of the study's operational meaning of TCO. In the present study, TCO refers to the perceived manageability of BIM-related complexity rather than to complexity as a purely inhibiting barrier. Accordingly, the positive coefficient indicates that organizations reporting stronger perceived manageability of BIM-related complexity were more likely to exhibit stronger BIM adoption (Ahmed & Kassem, 2018; Succar, 2009). This means that when BIM is viewed as understandable,

workable, and capable of being integrated into organizational procedures without excessive disruption, firms are more likely to move toward formal and continuing BIM uptake. The present finding is therefore consistent with the idea that organizations are more likely to adopt BIM when its technical, procedural, and coordination-related demands are perceived as manageable within the firm (Shirowzhan et al., 2020; Ullah et al., 2022). From a practical perspective, this implies that BIM adoption in Libya can be strengthened when organizations receive sufficient procedural guidance, implementation support, and internal capability development to make BIM-related complexity more manageable in actual practice (Ahmed & Kassem, 2018; Succar, 2009; Ullah et al., 2022).

5.3.7. Discussion of the TCOM and BIM Relationship

The results also showed that compatibility had a positive and statistically significant relationship with BIM adoption, with $\beta = 0.107$, $t = 3.044$, and $p = 0.002$, indicating that stronger perceived fit between BIM and the organization's existing workflows, systems, and operational needs was associated with stronger organizational BIM uptake (Shirowzhan et al., 2020; El Masry & Chron er, 2025). This finding is theoretically consistent with innovation-adoption research, which argues that organizations are more likely to formalize and sustain an innovation when it can be integrated into existing routines without excessive disruption (Baker, 2012; Ahmed & Kassem, 2018). In the BIM context, compatibility is especially important because BIM affects coordination processes, information handling, and interdepartmental interaction, which means that firms will be more willing to routinize BIM when it is perceived as workable within their established operational environment (Shirowzhan et al., 2020). Practically, this implies that BIM diffusion efforts in Libya should pay greater attention to organizational fit, workflow alignment, and gradual integration strategies, because technical value alone may not be enough unless BIM can be embedded within the firm's actual working system (El Masry & Chron er, 2025; Ahmed & Kassem, 2018).

5.3.8. Discussion of the OOR and BIM Relationship

Finally, the findings indicated that organizational readiness had a positive and statistically significant relationship with BIM adoption, with $\beta = 0.089$, $t = 3.145$, and $p = 0.002$. Although this coefficient was the smallest among the direct predictors, it remained statistically meaningful, which indicates that internal preparedness still

mattered for organizational BIM uptake in the Libyan construction sector (Magalhães et al., 2023; Ndwandwe et al., 2024). This result is theoretically important because organizations may recognize BIM's strategic value and still fail to move toward sustained adoption if they lack the knowledge base, implementation capability, structural preparedness, and process conditions necessary to support BIM in practice (Phung & Tong, 2021; Magalhães et al., 2023). The relatively smaller size of the coefficient suggests that readiness was not the strongest immediate driver in the present model, especially when compared with normative pressures and perceived relative advantage, but it still functioned as a meaningful enabling condition for BIM uptake. Practically, this means that Libyan construction organizations may require stronger internal preparation, training structures, process readiness, and capability development if BIM is to move from formal uptake into stable and continuing institutional practice (Ndwandwe et al., 2024; Magalhães et al., 2023).

5.4. Discussion of the Moderating Role of Corporate Culture

The moderating analysis showed that the interaction term between Normative Pressures and Corporate Culture had a positive and statistically significant relationship with Building Information Modeling adoption, with $\beta = 0.060$, $t = 2.124$, and $p = 0.034$, which indicates that the relationship between Normative Pressures and organizational BIM adoption became stronger when the internal cultural condition of the organization was more supportive of change, learning, collaboration, and innovation-oriented interpretation (Alankarage et al., 2023; Dai et al., 2018; Tavallaei et al., 2022). Although the size of the interaction coefficient was modest when compared with the direct relationship between Normative Pressures and BIM adoption, which remained the strongest direct predictor in the model, the result was still theoretically meaningful because it supports the view that external legitimacy-based pressures are not translated into organizational BIM uptake in a culturally neutral manner (DiMaggio & Powell, 1983; Tavallaei et al., 2022). In this sense, Corporate Culture in the present study should be understood as a focused internal conditioning mechanism rather than as a broad direct predictor of BIM adoption, which is fully consistent with the final conceptual position of the study and with the logic established in Chapter Two and Chapter Three (Alankarage et al., 2023; Behl et al., 2022; Dai et al., 2018).

5.5. Theoretical Implications

The present study makes several theoretical contributions to the BIM adoption literature. First, it strengthens the conceptual treatment of BIM adoption as an organizational innovation outcome rather than as a narrow software event or a purely individual-level technological response, which is consistent with the broader BIM literature that defines BIM as an organizational, process-based, and information-centered innovation within construction practice, as argued by Succar (2009) and Ahmed and Kassem (2018). By treating BIM adoption as an organizational condition reflected in formal uptake, institutional support, routinization, and continuity of use, the study contributes to greater conceptual precision in BIM research, especially in contexts where adoption is still emerging and where formal organizational uptake may precede mature implementation depth, as also implied by Ahuja et al. (2016) and Chowdhury et al. (2024). In this sense, the study contributes to the literature by reinforcing the need to distinguish clearly between adoption, implementation, and use when theorizing BIM in construction organizations, as emphasized by Succar (2009), Ahmed and Kassem (2018), and Chowdhury et al. (2024).

Second, the study contributes theoretically by supporting the value of the TOE framework as an integrative structure for explaining BIM adoption in construction organizations, while also showing that the environmental dimension becomes more analytically meaningful when interpreted through institutional theory, as proposed by Tornatzky and Fleischer (1990), Baker (2012), and DiMaggio and Powell (1983). The findings showed that technological, organizational, and environmental antecedents all had positive and statistically significant relationships with BIM adoption, which supports the broader proposition that BIM uptake is associated with multiple interacting domains rather than by one explanatory dimension alone, as argued by Tavallaei et al. (2022), Wang et al. (2025), and Chowdhury et al. (2024). This contributes to theory by moving beyond fragmented factor-by-factor BIM explanations and by supporting a more integrated organizational reading of BIM diffusion, particularly in developing construction environments where internal support conditions and external legitimacy pressures operate simultaneously, as indicated by Adekunle et al. (2021), Chowdhury et al. (2024), and Tavallaei et al. (2022).

Third, the study provides a more specific theoretical contribution within the environmental domain by showing that normative pressures were the strongest direct predictor of BIM adoption in the final model, which gives additional support to the institutional view that organizations adopt field-relevant practices not only for efficiency reasons but also because such practices become professionally legitimate and socially expected, as originally argued by DiMaggio and Powell (1983). In the BIM context, this finding is important because it supports the growing literature that treats BIM adoption as partly driven by standards, professional discourse, accepted practice, and legitimacy-oriented organizational response rather than by technical utility alone, as discussed by Tavallaei et al. (2022), Salem et al. (2025), and Chowdhury et al. (2024). The present study therefore contributes theoretically by demonstrating that the environmental context in BIM research should not be treated as a generic background category, but rather as a differentiated institutional field in which normative pressure may carry particular explanatory importance, especially in emerging and professionally transitional contexts such as Libya, as suggested by DiMaggio and Powell (1983), Tavallaei et al. (2022), and Salem et al. (2025).

Fourth, the study contributes theoretically through its focused treatment of Corporate Culture. Rather than modeling culture as a broad direct predictor of BIM adoption or as a universal moderator across all model relationships, the study positioned Corporate Culture as a focused internal conditioning mechanism in the relationship between normative pressures and BIM adoption, which is more conceptually disciplined and theoretically defensible, as supported by Alankarage et al. (2023), Dai et al. (2018), and Behl et al. (2022). The significance of the interaction effect suggests that external legitimacy-based pressures are not translated into organizational BIM uptake in a culturally neutral way, but are instead conditioned by whether internal values and norms support learning, collaboration, and openness to innovation-related change, which aligns with wider organizational theory and with BIM-related culture research, as discussed by Bogale and Debela (2024), Alankarage et al. (2023), and Tennakoon et al. (2022). The theoretical implication here is not that culture replaces technological or organizational explanations, but that it refines the boundary conditions under which normative pressure becomes more or less effective in producing formal organizational BIM uptake, which adds nuance to existing TOE and institutional explanations of BIM adoption, as indicated by Tavallaei et al. (2022), Dai et al. (2018), and Behl et al. (2022).

Finally, the study contributes to theory by extending BIM adoption research into the underexplored context of the Libyan construction sector, where BIM maturity remains limited and where organizational uptake must be understood under conditions of developing institutional infrastructure, uneven digital readiness, and transitional professional norms, as suggested by Elghdhan et al. (2023), Solla et al. (2023), and Solla et al. (2025). Much of the more consolidated BIM literature has emerged from more mature digital construction environments, whereas the present study tests the relevance of established adoption logics in a context where adoption remains less institutionalized and where external legitimacy pressures appear particularly important, as argued by Adekunle et al. (2021), Chowdhury et al. (2024), and El Hajj et al. (2023). The study therefore adds contextual depth to BIM adoption theory by showing that the combined explanatory power of TOE, institutional pressures, and focused cultural moderation remains relevant in a developing-country construction environment, while also indicating that the relative strength of the environmental domain may become especially pronounced under such conditions, as supported by Tavallaei et al. (2022), Adekunle et al. (2021), and Chowdhury et al. (2024).

5.6. Practical and Managerial Implications

The practical and managerial implications of the present study arise from the finding that Building Information Modeling adoption in the Libyan construction sector is associated with a combination of technological perceptions, organizational support conditions, environmental pressures, and a focused internal cultural condition, rather than with a single isolated driver alone. In practical terms, this means that BIM should not be approached merely as a software-acquisition decision. It should instead be managed as an organizational innovation process requiring formal commitment, procedural support, routinization, and sustained institutional backing within the firm, as emphasized by Succar (2009), Ahmed and Kassem (2018), and Ahuja et al. (2016). The present findings are especially important because they showed that all direct predictors were statistically significant, while normative pressures emerged as the strongest direct predictor of organizational BIM adoption in the final model, which suggests that BIM diffusion in Libya is likely to be accelerated when firms respond not only to technical value but also to professional legitimacy, accepted standards, and field-level expectations. This means that practical BIM advancement in Libya should be framed as

a strategic organizational and sectoral transition rather than as an isolated technical initiative (Succar, 2009; Ahmed & Kassem, 2018; DiMaggio & Powell, 1983).

At the firm level, the findings imply that managers should strengthen formal organizational commitment to BIM through explicit adoption decisions, internal procedures, stable implementation responsibility, and continuous allocation of organizational resources. Because BIM adoption in the present study was defined in terms of formal uptake, procedural support, current use, future expansion, and continued institutional commitment, firms should move beyond ad hoc or person-dependent BIM activity and instead create a more formalized structure for organizational BIM practice, as suggested by Ahmed and Kassem (2018), Ahuja et al. (2016), and Succar (2009). Senior management should therefore establish internal BIM policies, assign responsibility for implementation oversight, support cross-functional coordination, and embed BIM into routine managerial planning rather than treating it as an optional technical add-on. In practice, this means that BIM will be more sustainable when leadership support is visible, institutionalized, and tied to longer-term organizational priorities rather than depending on isolated enthusiasm from individual staff members. The present findings on the positive role of top management support reinforce the practical importance of executive sponsorship and organizational continuity in BIM-related change (Succar, 2009; Ahmed & Kassem, 2018; Ahuja et al., 2016).

The findings also carry important implications for how firms manage the technological side of BIM uptake. Since relative advantage and compatibility were positively associated with organizational BIM adoption, managers should actively demonstrate the practical value of BIM and ensure that implementation is aligned with existing workflows, project requirements, and organizational routines. This means that successful BIM adoption is unlikely to emerge from general advocacy alone. It requires a structured managerial effort to show where BIM improves coordination, information flow, visualization, and project control, while also adapting implementation pathways to the operational realities of the firm, as argued by Succar (2009), Ahmed and Kassem (2018), and Ahuja et al. (2016). In practical terms, firms should begin with clearly scoped use cases, phased implementation plans, and workflow-compatible pilot

applications that reduce disruption and allow organizational learning to develop incrementally. This is particularly important in contexts such as Libya, where full-scale digital transformation may be constrained by institutional and operational conditions, and where perceived organizational fit can determine whether BIM remains symbolic or becomes embedded in actual practice. The significance of compatibility in the model therefore indicates that implementation strategies should be gradual, context-sensitive, and structurally aligned with how firms currently work, rather than imposed as abstract digital reforms (Succar, 2009; Ahmed & Kassem, 2018; Ahuja et al., 2016).

At the sectoral level, the strongest practical implication concerns the role of normative pressure. Because normative pressures recorded the largest direct coefficient in the final model, the findings suggest that BIM diffusion in Libya is especially likely to advance when BIM becomes increasingly normalized as the accepted and professionally legitimate way of working across the construction field. This has direct implications for professional associations, universities, training bodies, public agencies, and industry regulators. These actors should work to strengthen BIM-related standards, technical guidance, continuing professional education, curriculum integration, and sectoral awareness, because such mechanisms increase the legitimacy and expectedness of BIM within the organizational field, as explained by DiMaggio and Powell (1983). In practice, this means that Libya may benefit from a coordinated ecosystem approach in which professional expectations, educational exposure, and industry guidance move together, thereby making BIM adoption less dependent on individual firm initiative and more strongly anchored in accepted sectoral practice. The present findings therefore imply that the acceleration of BIM in Libya requires institutional and professional reinforcement, not just firm-level experimentation (DiMaggio & Powell, 1983; Ahmed & Kassem, 2018; Succar, 2009).

The results further imply that policymakers and major project clients can play a constructive role in strengthening BIM uptake through soft and formal external signals. Since mimetic and coercive pressures also showed positive and significant relationships with BIM adoption, the findings indicate that organizations respond to what leading firms do and to what powerful external stakeholders expect. This means that large public

clients, state-linked agencies, and major private developers can influence BIM diffusion by including BIM expectations in procurement language, tender evaluation, technical guidelines, or preferred project-delivery standards. Even when hard mandates are not immediately feasible, the sector can still be influenced through demonstration projects, preferred practice frameworks, and visible endorsements from leading institutions. In this sense, the practical implication is that BIM diffusion in Libya should be supported through a mixed strategy of professional normalization, visible exemplars, and gradual external encouragement, rather than waiting for spontaneous market-wide adoption to emerge on its own (DiMaggio & Powell, 1983; Ahuja et al., 2016; Ahmed & Kassem, 2018).

A further managerial implication arises from the moderating role of Corporate Culture. Although the interaction effect was modest in magnitude, it was statistically significant, which means that the relationship between normative pressures on BIM adoption became stronger when internal organizational culture was more supportive of learning, collaboration, and innovation-oriented interpretation. This is practically important because it shows that external pressure alone may not be enough to produce sustained BIM uptake if the internal environment of the firm is resistant to change or weak in collaborative and learning-oriented practices, as suggested by Alankarage et al. (2023), Behl et al. (2022), and Dai et al. (2018). Managers should therefore not treat culture as an abstract background issue. They should actively cultivate a work environment that supports knowledge sharing, interdepartmental cooperation, openness to new methods, and managerial encouragement for innovation-related change. In practice, this means that firms should link BIM-related training, implementation planning, and internal communication with broader efforts to strengthen organizational learning and collaborative work culture. The present study therefore implies that internal cultural development is not separate from BIM strategy, but part of the managerial conditions that enable normative expectations to become actual organizational commitment and sustained BIM-related practice (Alankarage et al., 2023; Behl et al., 2022; Dai et al., 2018).

Finally, the results suggest that Libyan construction organizations should treat BIM adoption as a staged organizational transformation rather than as a single one-time decision. The significance of organizational readiness, even though its direct coefficient was smaller than those of normative pressures and relative advantage, indicates that internal capability, preparedness, and process support still matter in sustaining organizational BIM uptake. Practically, this means that firms should invest in staff preparation, internal procedures, role clarity, and implementation support structures if BIM is to become stable and routinized within organizational practice. Managers should therefore combine strategic commitment with incremental capability building, while policymakers and professional institutions should support these efforts through training programs, applied guidance, and sector-relevant implementation frameworks. The broad practical implication of the present study is that successful BIM uptake in Libya will be more likely when firms and institutions act on multiple fronts at once, namely organizational commitment, workflow alignment, sectoral legitimacy, supportive external signals, and internal cultural readiness for change. In this sense, the findings provide a practical roadmap for moving BIM from limited organizational uptake toward more stable institutionalization within the Libyan construction sector (Succar, 2009; Ahmed & Kassem, 2018; Ahuja et al., 2016; Alankarage et al., 2023).

5.7. Limitations of the Study

Like all empirical research, the present study is subject to a number of limitations that should be acknowledged when interpreting its findings. First, the study adopted a quantitative cross-sectional design, which means that the data were collected at a single point in time and therefore do not capture how Building Information Modeling adoption may evolve across different stages of organizational change or over longer periods of institutional development (Ponto, 2015; Sekaran & Bougie, 2019). As a result, the findings should be interpreted as evidence of statistically significant relationships among the study constructs rather than as proof of temporal causality. This limitation is particularly relevant in BIM research because organizational uptake, routinization, and cultural interpretation may develop progressively rather than instantaneously, especially in emerging and low-maturity construction contexts such as Libya (Succar, 2009; Ahmed & Kassem, 2018). Accordingly, the present results should be understood as a

cross-sectional explanation of organizational BIM adoption rather than as a longitudinal account of how adoption unfolds over time.

Second, the study relied on self-reported questionnaire responses from professionals working in the Libyan construction sector, which means that the empirical evidence reflects informed respondent perceptions rather than audited organizational records or direct observation of BIM practice (Ponto, 2015; Evans & Mathur, 2018; Sekaran & Bougie, 2019). This is an important limitation because respondents may differ in their interpretation of organizational conditions, their level of familiarity with BIM-related practices, and their perception of the degree to which BIM is formally embedded within their organizations. Although this approach is common and methodologically acceptable in explanatory survey research, it still means that the findings should be interpreted as perceived organizational patterns rather than as fully objective firm-level measures. This limitation is especially relevant in the present study because BIM adoption was examined as an organizational-level construct through respondent-based indicators of formal uptake, organizational support, routinization, and continuity of BIM-related practice (Ahmed & Kassem, 2018; Ahuja et al., 2016; Succar, 2009).

Third, although the present study treated BIM adoption as an organizational innovation outcome, the dependent construct captures organizational BIM adoption through indicators of formal decision, current project use, procedural support, organizational backing, future expansion intention, routinization, and continued resource commitment, rather than through a narrow binary adoption decision alone (Ahmed & Kassem, 2018; Ahuja et al., 2016; Succar, 2009). This is a strength in terms of organizational realism, but it is also a limitation in interpretive terms, because the construct reflects organizational uptake and institutionalization rather than a simple yes-or-no adoption state. The findings should therefore be interpreted as evidence concerning the degree of organizational BIM adoption and practical institutional uptake within the firm, not as a direct audit of mature implementation depth across all projects or lifecycle stages. This distinction is important because BIM research increasingly differentiates between adoption, implementation, and use, and the present study is more closely aligned with organizational uptake and continuing institutionalization than with post-adoption performance maturity alone (Succar, 2009; Ahmed & Kassem, 2018).

Fourth, the study examined a selected set of variables derived from the TOE framework, Institutional Theory, and a focused cultural moderation perspective, but it did not include all possible predictor of BIM adoption in construction organizations (Baker, 2012; DiMaggio & Powell, 1983; Tavallaei et al., 2022). Other relevant factors may also shape BIM adoption in the Libyan construction sector, including contractual arrangements, firm size, project type, software ecosystem issues, procurement structures, client sophistication, and broader political-economic conditions. The present model was intentionally delimited in order to preserve conceptual coherence and analytical focus, especially by restricting the moderating role of Corporate Culture to the relationship between Normative Pressures and BIM adoption only. Nevertheless, this means that the explanatory scope of the model, although meaningful and statistically supported, should not be interpreted as exhaustive of all drivers of organizational BIM uptake in Libya.

Fifth, the study was conducted in the Libyan construction sector and drew on a sample of professionals who were accessible during the data collection period through online distribution channels, including Google Forms and professional communication networks (Evans & Mathur, 2018; Sekaran & Bougie, 2019). While this approach was appropriate and practical for reaching the target respondents, it may limit the generalizability of the findings to all construction organizations in Libya or to other national construction contexts with different institutional conditions and levels of BIM maturity. The results are therefore most appropriately interpreted as context-sensitive evidence concerning BIM adoption in Libya rather than as automatically generalizable conclusions for all developing-country construction sectors. This contextual limitation does not weaken the value of the study, but it does mean that the findings should be generalized cautiously and with due consideration of the specific institutional and professional characteristics of the Libyan construction environment (Adekunle et al., 2021; El Hajj et al., 2023; Elghdban et al., 2023).

Finally, the moderating relationship between Corporate Culture, although statistically significant, was modest in magnitude when compared with the strongest direct relationships in the model, especially the direct relationship between Normative Pressures. This means that the findings support the theoretical relevance of Corporate Culture as a focused internal conditioning mechanism, but they should not be interpreted

as evidence that culture overrides the direct influence of environmental, technological, or organizational factors (Alankarage et al., 2023; Dai et al., 2018; Tavallaei et al., 2022). Rather, the present study suggests that culture refines the conditions under which normative pressures are more effectively translated into organizational BIM adoption. This is an important but bounded implication, and it should be interpreted within the conceptual limits of the model and the empirical constraints of the study design. Taken together, these limitations indicate that the present study provides meaningful and contextually valuable evidence on BIM adoption in Libya, while also leaving important room for future research to strengthen construct precision, broaden model scope, and test the findings through alternative designs and settings (Ahmed & Kassem, 2018; Alankarage et al., 2023; Tavallaei et al., 2022).

A further limitation of the present study concerns the possibility of common method bias. Since the principal constructs were measured through a single self-reported questionnaire administered at one point in time, some degree of shared method variance may have affected the observed relationships among the variables, which is a recognized concern in cross-sectional behavioral and organizational research based on a single measurement source (Podsakoff et al., 2003; Ponto, 2015). This does not invalidate the results of the study, but it does mean that the statistically significant relationships identified in the structural model should be interpreted with methodological caution, especially in terms of possible inflation in the strength of some associations due to common measurement context rather than to substantive theoretical relationships alone (Podsakoff et al., 2003; Hair et al., 2019). Accordingly, the findings of the present study are best interpreted as meaningful empirical evidence within the limits of a cross-sectional self-report design rather than as method-free estimates of organizational reality (Ponto, 2015; Hair et al., 2019).

5.8. Recommendations for Future Research

Future research should extend the study of Building Information Modeling adoption in ways that improve temporal depth, construct precision, and contextual generalizability. Since the present study adopted a cross-sectional survey design, future researchers are encouraged to employ longitudinal designs that can capture how organizational BIM adoption develops over time, particularly across the stages of formal decision, early uptake, routinization, and wider institutional embedding within firms, as

discussed by Succar (2009) and Ahmed and Kassem (2018). Such designs would be especially useful in developing construction contexts, where BIM-related organizational change may unfold gradually and where the transition from symbolic or partial uptake to more stable institutionalization may require time to become observable in a rigorous way, as suggested by Ahuja et al. (2016) and Ponto (2015). Future studies could therefore investigate whether the relative importance of technological, organizational, and environmental factors remains stable over time or whether different predictor become more influential at different stages of BIM adoption, implementation, and use, as implied by Succar (2009), Ahmed and Kassem (2018), and Ahuja et al. (2016).

Future research should also refine the measurement of key constructs in BIM adoption models. Although the present study treated BIM adoption as an organizational-level construct reflecting formal uptake, institutional support, routinization, and continuity of BIM-related practice, future researchers may benefit from distinguishing more explicitly between adoption, implementation, use intensity, and post-adoption performance outcomes, as emphasized by Succar (2009) and Ahmed and Kassem (2018). This would allow future studies to examine whether the same predictor influence the decision to adopt BIM, the capacity to implement it, the depth of use across projects, and the organizational outcomes that emerge after BIM becomes embedded in regular practice. Such construct differentiation would strengthen conceptual precision in BIM research and reduce the possibility of overlap between antecedents, uptake indicators, and downstream performance effects, which remains an important methodological issue in innovation-adoption studies more broadly, as indicated by Ahmed and Kassem (2018), Succar (2009), and Ahuja et al. (2016).

A further recommendation concerns the role of organizational culture. The present study supported the relevance of Corporate Culture as a focused moderator of the relationship between Normative Pressures and BIM adoption, but future studies should examine culture in greater conceptual depth and with broader methodological variety. In particular, future researchers should investigate which specific cultural dimensions, such as openness to change, collaborative orientation, learning support, managerial trust, or innovation tolerance, are most influential in strengthening or weakening the organizational response to BIM-related legitimacy pressures, as suggested by Alankarage et al. (2023), Behl et al. (2022), and Dai et al. (2018). It would

also be valuable to test alternative moderation structures, mediating mechanisms, or more differentiated cultural frameworks in order to determine whether culture operates primarily as an internal conditioning factor, a direct predictor, or a more complex organizational context within BIM-related transformation. Such work would contribute to a more mature integration of culture into BIM adoption theory and would deepen the explanatory relationship between internal organizational interpretation and external institutional pressure, as argued by Alankarage et al. (2023), Dai et al. (2018), and Behl et al. (2022).

Future research should also employ mixed-method and qualitative designs to complement the explanatory strengths of survey-based PLS-SEM models. While quantitative modeling is useful for identifying statistically significant relationships among constructs, qualitative and mixed-method studies could provide richer insight into how BIM adoption is interpreted, negotiated, resisted, and normalized within organizations and across projects, which is particularly important in construction settings characterized by coordination intensity, fragmented project structures, and varying professional roles, as emphasized by Succar (2009) and Alankarage et al. (2023). Interviews, case studies, and organizational process tracing would be especially valuable for understanding why normative pressures become more influential in some firms than in others, how internal culture shapes BIM-related decision processes, and how organizations practically move from formal commitment toward routinized BIM use. Such methodological expansion would help future research capture the lived organizational dynamics behind statistical relationships and would therefore strengthen both theoretical and practical understanding of BIM diffusion in developing construction environments, as suggested by Ponto (2015), Alankarage et al. (2023), and Ahmed and Kassem (2018).

In addition, future research should expand the contextual scope of BIM adoption studies beyond single-country and single-sector analyses. Because the present study focused specifically on the Libyan construction sector, future studies may compare Libya with other MENA countries, other developing construction contexts, or more digitally mature construction environments in order to determine whether the relative strength of environmental pressures, organizational conditions, and cultural moderation remains stable across settings, as implied by DiMaggio and Powell (1983), Ahuja et al.

(2016), and Ahmed and Kassem (2018). Comparative studies of this kind would be particularly useful for identifying whether strong normative pressure is a context-specific feature of institutionally transitional environments or a more general pattern in BIM adoption across construction sectors. Such cross-context comparison would also contribute to greater external validity and would help future theory-building distinguish between universal adoption mechanisms and context-dependent institutional dynamics, as suggested by DiMaggio and Powell (1983), Ahmed and Kassem (2018), and Ahuja et al. (2016).

Finally, future researchers are encouraged to incorporate more objective and organization-linked indicators where possible. Although perceptual measures remain valuable and widely used in organizational research, future BIM studies could be strengthened by integrating additional evidence such as organizational BIM policies, documented BIM workflows, project-level BIM usage records, training investments, software deployment structures, or multiple informants from the same firm, in order to reduce dependence on single-respondent perception and to strengthen the organizational validity of the findings, as suggested by Ahmed and Kassem (2018), Ahuja et al. (2016), and Ponto (2015). Future research may also use multilevel or multi-informant designs to distinguish more clearly between individual perception, organizational policy, and project-level practice, especially in contexts where BIM adoption is still uneven and organizational experience varies substantially across firms. In this sense, the most productive future direction for BIM adoption research is likely to involve greater construct precision, richer methodological design, broader contextual comparison, and stronger linkage between organizational theory and observable BIM-related practice, as argued by Succar (2009), Ahmed and Kassem (2018), Alankarage et al. (2023), and Ahuja et al. (2016).

5.9. Conclusion

This study set out to explain Building Information Modeling adoption in the Libyan construction sector through an integrated model combining technological, organizational, and environmental predictors within a TOE-based framework, while also incorporating Corporate Culture as a focused moderating variable in the relationship between Normative Pressures and BIM adoption. The study responded to the persistent problem that BIM, despite its recognized value in improving coordination, information

management, and project effectiveness, remains unevenly adopted and insufficiently institutionalized in many developing construction environments, including Libya. Within this context, the present research treated BIM adoption as an organizational-level outcome and examined the extent to which technological perceptions, organizational support conditions, and environmental legitimacy pressures were statistically associated with stronger organizational uptake of BIM in Libyan construction firms. The findings showed that all the direct relationships in the final model were positive and statistically significant, and that the model also demonstrated meaningful explanatory power and acceptable fit, thereby providing empirical support for the final conceptual structure of the study. Among the direct predictors, Normative Pressures emerged as the strongest direct predictor of BIM adoption, followed by Relative Advantages and Mimetic Pressures, while Coercive Pressures, Top Management Support, Complexity, Compatibility, and Organizational Readiness also remained statistically significant. This overall pattern indicates that BIM adoption in Libya was statistically associated with multiple technological, organizational, and environmental conditions rather than with a single isolated factor. The findings therefore support the view that BIM adoption is best understood as an organizational and institutional process rather than as a narrow technical or software-level event alone. In particular, the prominence of Normative Pressures suggests that professional expectations, accepted standards, and field-level legitimacy pressures are closely associated with stronger organizational BIM adoption in the Libyan construction sector. This interpretation reinforces the value of combining the TOE framework with Institutional Theory in order to explain BIM adoption in emerging and transitional construction contexts. The study also concludes that Corporate Culture plays an important but bounded role in the BIM adoption process. The moderating analysis showed that the interaction between Normative Pressures and Corporate Culture was positive and statistically significant, which indicates that the relationship between Normative Pressures and BIM adoption became stronger when the internal cultural condition of the organization was more supportive of collaboration, learning, change, and innovation-oriented interpretation. Although this moderating effect was more modest than the strongest direct paths in the model, it remained theoretically meaningful because it showed that external professional and legitimacy-based pressures are not interpreted or enacted in a culturally neutral way. Instead, internal culture conditions show how such pressures are translated into organizational BIM

adoption. This means that BIM diffusion in Libya depends not only on stronger standards, guidance, and professional expectations in the wider field, but also on internal organizational conditions that make firms more receptive to such pressures. In this sense, the present study suggests that BIM adoption in Libya is associated with the interaction of institutional legitimacy, organizational support, perceived technological value, and supportive cultural interpretation rather than with any one factor alone.

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CURRICULUM VITAE

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