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FULL LENGTH ARTICLE

Quantifying the ISO 19650 Dividend: Developing Practical KPIs for BIM Implementation ROI

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ABSTRACT

Purpose – The current global transformation in the construction industry, through the use of Building Information Modeling (BIM) and ISO 19650 information management, is hindered by a missing financial Return on Investment (ROI) on the ISO 19650 information management. This is a hindrance for investment and decision- making. The research seeks to solve the problem through the establishment of a Key Performance Indicator (KPI) for the realization of the "ISO 19650 Dividend." Design/methodology/approach – A sequential explanatory mixed-methods approach was adopted, integrating a systematic literature review, the analysis of existing data (n = 104), a cross-sectional study involving a primary survey of a targeted cohort in the UK and Saudi Arabia ($n = 187$), and in-depth expert interviews ($n = 15$). Quantitative data were analysed using weighted mean, gap, and path analyses, while qualitative data were examined through thematic analysis. Findings – The paper pinpoints the attainment of operational efficiency and cost competitiveness as the key priority level for the value drivers, while pointing out the substantial gap in measuring the intangible value, such as organization capital and sustainability. Commitment to the organization by the leaders stands as the key critical success factor. The key outcome of this paper includes the development of the four-leveled KPI Framework and the conceptual model focusing on the adoption and successful measurement, resulting in the ROI a. Practical implications – The framework offers a structured roadmap or a step-by-step process change that enables organizations to move from basic process compliance measurement metrics to financial metrics measurement in their digital projects. This framework provides professionals in this domain a way in which benefits realized from collaboration are converted into a proxy measures. Originality/value – Instead, this research breaks the mold of general sets of BIM benefits in offering the first-ever integrated measurement framework that specifically sets out to quantify the ROI of implementing ISO 19650, by synthesizing performance metrics with qualitative knowledge of leadership and change management in a holistic approach for the realization of digital promise and profit .

Keywords: Building Information Modeling (BIM) ▪ ISO 19650 ▪ Return on Investment (ROI) ▪ Key Performance Indicators (KPIs) ▪ Digital Transformation ▪ Construction Industry

1. INTRODUCTION

The construction industry as a whole is witnessing a paradigm shift as a result of the influence of digitization and the integration of Building Information Modeling (BIM), which has become the key outcome and process for this technology change. With the adoption of the global standard for information management, ISO 19650, the most pressing economic question being addressed by the industry as a whole relates to the ROI analysis for the significant investment made by the industry on such technology advancements, as the value addition demonstrated by the industry through the use of BIM on individual projects, such as a minimized number of design ch anges, the minimized number of request for information (RFI), and coordination, has not been addressed adequately by the current literature [1]. The fact that many benefits, such as improved collaboration or increased job satisfaction, are often intangible and thus difficult to quantify, leading to a valuation gap between the hard costs incurred and

the long-term benefits that may be realized. This tends to be the main challenge standing in the way of wide adoptions, especially in emerging markets where the re are competing investment priorities. In particular, this is because many benefits often tend to be quite intangible and hard to quantify, which causes a valuation gap between hard costs incurred and the potential long-term benefits. This situation tends to slow down the pace of digital transformation, making it hard for managers to obtain internal funding, as well as hampers the development of evidence-based adoption strategies. The literature confirms that the majority of current studies on BIM value rely heavily on qualitative case studies and practitioner self-reports [1]. While these provide a useful contextual background, there is often a lack of standard, applicable set of KPIs that an organization can apply to monitor performance and systematically evaluate success through the full project lifecycle. Moreover, the existing literature places an uneven focus on the design and build phases, with relative neglect of value measurement in the operation and maintenance phase, where the majority of asset l ifecycle costs accumulate [1]. This situation creates an urgent need to develop a practical framework that addresses the shortcomings of current measurement and goes beyond simply demonstrating benefits to providing applicable tools for calculating return on investment. Transformational and participatory leadership styles will lead to successful adoption of standards like ISO 19650, as demonstrated in this master's thesis that collected information from 104 professionals in the UK and Saudi Arabia. The implementation of these standards is not an isolated activity; rather, it represents a change journey for any organization using such standards, requiring proper leadership and systematic approaches to change management [2]. A key benefit of applying Systematic Change Management (SCM) frameworks, like Kotter's 8- Steps, is that they help organizations successfully manage their workforce through the change process by reducing resistance and embedding new processes. Nevertheless, the findings of the study indicate that businesses continue to struggle with their ability to effectively realize the benefits of digital transformation as many organizations do not have a defined benefit realization process in place or utilize KPIs that are aligned with their digital transformation goals [2]. The importance of leadership and change is well established; however, there exists a large gap in our ability to quantify these organizational factors in terms of improved performance outcomes that allow for an estimate of the return on investment. In support of this view, a number of recent studies have established the connection between certain styles of leadership (e.g., inspirational or contingent reward) and BIM project performance through improved coordination effectiveness [3]. This paves the way for understanding the causal relationship between leadership behavior and tangible achievement. The context of BIM implementation and its standards has distinct differences between established digital markets eg Uk and fledgling digital market (Saudi Arabia) driven by Government mandate in relation to establishing BIM. In the case of the UK where there is a robust regulatory framework that has been created, creating a strong external motivation to support the use of BIM. The issue in the UK is getting the Industry to embrace BIM on a cultural basis where as Saudi Arabia are unique, faced with challenges around Claims and Disputes due to variations in scope and payment delays [4]. According to research, BIM can assist in reducing the number of disputes that arise from certain sources through its adoption. This has the potential to provide a significant return on investment (ROI) in the Saudi Arabian market by lowering the costs of resolving claims through legal and administrative channels. Therefore, an organization's Key Performance Indicator (KPI) framework should be adaptable enough to capture the various ways in which this technology creates value in different market environments, allowing for customization of measurement against business objectives and local market conditions. The research paper will create and provide a useful framework for a comprehensive and actionable set of Key Performance Indicators (KPIs) that will allow construction organizations to measure and achieve the return on investment (ROI) of ISO 19650 implementation. The findings of this research will be enhanced by the wealth of information provided by an earlier field study database [2], which included a quantitative survey of 104 participants and in-depth interviews with 7 senior practitioners. The proposed framework will: 1. Classify KPIs across multiple dimensions: operational (e.g., workflow efficiency, data accuracy), financial (e.g., cost savings, ROI), strategic (e.g., digital maturity, competitive advantage), and compliance. 2. Clearly link KPIs to the project lifecycle phases (design, construction, operation, and maintenance) to ensure timely measurement. 3. Propose a methodology for calculating return on investment that integrates tangible and intangible indicators, while acknowledging that some benefits may only materialize in the long term. 4. Integrate insights from leadership theory and change management to illustrate how organizational factors influence the achievement of key performance indicators (KPIs).

2. LITERATURE REVIEW

2.1 Overview

BIM has been defined in various ways [1,5]. For example, it has been defined as a process for creating and using digital models for design, construction, and operations [6], or as a shared knowledge resource forming a reliable basis for decisions throughout a facility's lifecycle [7]. A more contemporary perspective views BIM as a foundational element within a broader digital transformation, driven by data and integrated with standards like ISO 19650 for information management [8]. Several researchers have cited the benefits of BIM, including reduced design errors, fewer requests for information (RFIs), improved schedule performance, and enhanced collaboration [1,5]. Nevertheless, despite the existence of evidence demonstrating the project-level advantages of using BIM, there is still a major obstacle to be overcome in calculating a standardized and predictable return on investment (ROI) for digitalization initiatives. This gap between the documented value of projects that have used BI M versus the organization's capacity to measure the return on invest-

Table 1. Key factors influencing BIM value realisation and ROI.

No.	Key Factor	Authors
Strategic and Organizational Factors		
1	Leadership & Vision: Transformational and involving leadership styles that inspire teams and manage change.	[2,3,10]
2	Change Management: Application of structured frameworks (e.g., ADKAR, Kotter) to mitigate resistance and embed new processes.	[2,9]
3	Human Capability & Skills: Technical competence, collaboration skills, and change readiness of staff.	[1,14]
4	Performance Measurement Culture: Organizational focus on defining and tracking KPIs for digital initiatives.	[5,8]

ments made in the form of digital tools serves as a barrier to broader adoption of these tools and the identification of strategic drivers to justify implementing them [1]. The main barrie rs to realising this value extend beyond the traditional technical hurdles of interoperability and software cost. They now increasingly include organizational and human factors such as behavioural resistance to change, a lack of leadership competencies suited to digital collaboration, and the absence of a clear methodology for measuring intangible benefits [1,9,10].

2.2 Key Factors Influencing BIM Value Realisation and ROI

Many researchers have stated that the primary drivers for successful implementation and realisation of the value of BIM technology are a change from simply recognising its benefit to actively managing its use as a Change Management Programme within an Organisation. The main areas for constructing a leveraging ability include: a) Leadership, b) Management in an Organisational Environment, c) Performance Measurement Development Systems. Clear metrics and KPIs related to strategic goals are critical to translate the use of BIM into measurable value. Leadership approaches that promote digital coordination and reduce resistance to change are equally important when managing the transformation process. Also, organisations should look to the future and integrate BIM into their Enterprise performance dashboard [8,11,12,13]. [1] argued that the development of a standardized method for quantifying BIM investment value and a deeper exploration of intangible benefits are the primary research gaps needing attention. According to [14], one of the most significant factors that determine the success of BIM transformation is the Human Capability, and they further state that to be successful at BIM transformation, an organization must create a synergy of technology support, collaboration between the organization and its partne rs, capability -building techniques, and government and industry policy initiatives. Similarly, [2] stated that organizations should pursue transformational leadership along with an established change management process (such as Kotter's 8 -Step Model) as a means of accelerating BIM value realisation and eliminating internal limitations. The contemporary literature review also identifies key factors affecting BIM value realisation and ROI, as demonstrated in Table 1 .

Different studies identify different influential variabl es or elements that may all share some commonalities; however, some studies will have shared aspects while others will have none at all. In synthesising the above information it is clear that the interaction between the various influencers is the key to ob taining a measurable return on investment. For example, strong leadership allows for effective change management which in turn will improve employee capability and follower adherence to processes, all of which can be measured through enhanced performance metrics.

2.3 Towards a Practical KPI Framework for Measuring BIM/ISO 19650 ROI

Many researchers have proposed that there should be available a robust and practical framework through which to evaluate the benefits of BIM. According to [1] in their systematic review on BIM benefits and risks, they identified that the lack of a standardised methodology to determine ROI was a significant gap. They identified the quantifiable benefit factors that include productivity; reduced changes/rework; r educed RFIs; better schedule efficiency; improved safety; improved sustainability; and improved FM. A proposed Data -Driven Decision (DDD) Framework was developed by [8] and used as the basis to treat digitalisation as a source of information, which is fed into the DDD Framework. The DDD Framework defines a concise set of Key Performance Indicators (KPIs) related to things other than just the project budget and schedule, including Velocity, Lead/Cycle Time, Burn Rate and Risk Exposure Index (REI), which can be integrated into real-time dashboards. The DDD Framework meets the need for a more dynamic and integrated way of measuring performance.

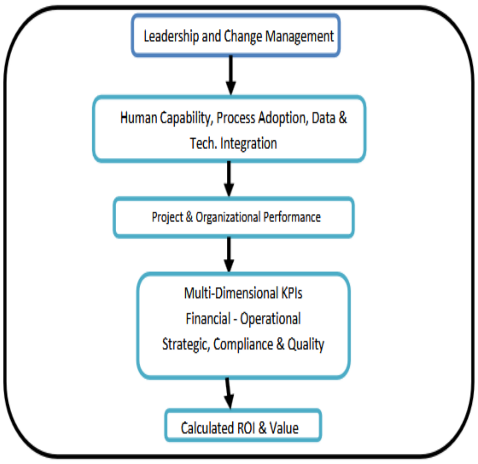

Figure 1. Conceptual model for an integrated BIM/ISO 19650 ROI KPI framework.

The KPI Framework for ISO 19650/BIM ROI will be multi -dimensional and should reflect the Human and Organisational Factors. A Comprehensive KPI Framework that integrates key influencing factors (from Table 1) into measurable outcome KPIs is illustrated in Figure 1, which depicts a Proposed Conceptual Model as developed from the research data.. The framework suggested by this synthesis involves:

3. **Categorising KPIs across multiple dimensions:** Financial (e.g., cost savings, ROI), Operational (e.g., RFI reduction, clash resolution time), Strategic (e.g., digital maturity score, bid win rate), and Compliance (e.g., on-time information deliveries, EIR compliance rate).

4. **Linking KPIs to project lifecycle phases:** Ensuring measurement during Design (e.g., design error cost), Construction (e.g., rework ratio), and Operations (e.g., energy efficiency vs. BIM model).
5. **Incorporating leading and lagging indicators:** Combining input metrics like training completion rates (leading) with output metrics like schedule performance (lagging).
6. **Providing a calculation methodology:** Developing formulas that can integrate tangible cost savings with proxies for intangible benefits (e.g., assigning a monetary value to reduced claim settlement time).

In spite of many approaches such as systematic reviews [1], data frameworks [8], and factor analyses [14], currently there is no standardized, concise, or comprehensive methodology to evaluate how much value can be derived from using the newly developed ISO 19650 standards in terms of Building Information Modelling (BIM). The complexities associated with integrating social and technical aspects into determining value, as well as the variability in value that exists based on the situation, make it extremely difficult to determine what ROI (Return on Investment) will come from implementing the standards. For this reason, this study will create and validate an easily understood summary of KPIs (Key Performance Indicators) that quantify the potential "ISO 19650 Dividend" (the financial gain) using empirical evidence collected from earlier studies conducted in the same industry [2], to bridge this critical gap between theory and practice.

3. RESEARCH METHODOLOGY AND DATA COLLECTION

3.1 Method of data collection

A sequential interpretive mixed method research de sign (IID) was used to develop and validate a practical framework for measuring return on investment (ROI) for implementing ISO 19650 standard(s) in order to reach the main research aim. The IID framework consisted of three sequential phases (as shown in Figure 2), with each phase relying on the results of the previous phase to provide the necessary data for the next. This structure is the best way to develop a strong framework, as it includes a diverse set of generalizable quantitative data and a rich collection of qualitative interpretative data. Phase 1: Theoretical Foundation and Secondary Exploratory Analysis This phase aimed to establish the initial intellectual and empirical foundation for the research and comprised two concurrent tracks: 1. Rigorous Systematic Literature Review: A comprehensive systematic review of relevant academic and professional literature was conducted, organized around three strategic axes: a) Challenges and frameworks for measuring BIM value and ROI, with a focus on the gap between p roven benefits and standardized quantitative measurement [1]. b) Critical organizational and behavioral factors for successful adoption, such as the role of transformational and participatory leadership styles [11] and the effectiveness of systematic change management frameworks such as Kotter's model [2]. c) Previous attempts and recent proposals for developing key perf ormance indicators (KPIs) and data -driven decision frameworks in digital construction projects [8]. This review aimed to accurately identify the knowledge gap and establish a robust conceptual framework for further research. 2. Exploratory Secondary Quantitative Analysis: To build upon the initial empirical evidence base, a secondary quantitative analysis was conducted on a comprehensive dataset from a previous field study [2]. This dataset comprised responses from 104 p rofessionals from the UK and Saudi Arabia via a structured questionnaire. The analysis, conducted using SPSS version 28, employed the following statistical methods: o Descriptive statistics: to calculate frequencies, percentages, means, and standard deviations for demographic characteristics and principal variables. o Correlation analysis (Pearson correlation coefficient): to identify primary relationships and correlations between principal variables such as the prevailing leadership style, the degree of adopti on of ISO 19650 practices, and perceived operational outcomes.

This analysis aimed to generate preliminary hypotheses and understand the relationships between organizational factors and project outcomes, providing initial trends that can be further tested in the next phase. Phase Two: Collection and Analysis of Primary Quantitative Data via an Online Survey This phase was designed to collect generalizable data from a broader sample to identify value priorities, critical success factors, and practical challenges associated with measuring ROI for BIM/ISO 19650. Method for Distributing and Collecting Respondents: An online structured survey was created. The first version of this structured online survey was tested by eight experienced BIM Project Management pro fessionals based in both the UK and Saudi Arabia that each had more than 10 years of experience in the use of BIM during construction projects. Based upon their feedback the wording and the order of the items on the first version of the structured online survey were modified to improve the validity and clarity of the instrument. Finally, the survey was posted on Google Forms and distributed to individuals in the target population via email and through social media channels: o Professional networking channels (e.g., LinkedIn). o UK and Saudi Arabia industry groups and forums. o Direct email to targeted lists of construction companies. Sampling Data and Sampling Methodology: Because of the uniqueness of the study's aims and objectives, a non- probability purposive s ampling method was employed to identify subjects who are aware of and have used the product or process being researched. The targeted populations are as follows: BIM or Information Management, Project and Construction Management, Digital Transformation, Qu antities/Cost, and Executive Level Personnel. The target sample size was determined using Equation 1 – the statistical formula for determining sample size for a known population: $n = N / (1 + N(e^2))$ ... (Equation 1) where: o N is the estimated total popu lation size (the number of qualified professionals in the UK and Saudi Arabian markets). Based on figures from professional councils and the industry, it was estimated at 200,000. o e is the acceptable margin of error, chosen at 7% (0.07) to balance accuracy and feasibility. o n is the required sample size. Calculation: $n = 200{,}000 / (1 + 200{,}000 \times (0.07)^2) \approx 204$ The data was cleaned, and the total valid and complete response count is 187, which is very close to the desired total and provides an excellent database to support the advanced statistical analyses that will be p erformed. The questionnaire collected the opinions from respondents about value dimensions as well as success factors so that their importance and ways to measure them are measured using a

Likert-type scale ranging from 1 = "Strongly Disagree"2 = "Disagree", 3 = "Neutral" 4 = "Agree" 5 = "Strongly Agree". Quantitative Analysis Methodology: To analyze the questionnaire data, a set of statistical methods was used in SPSS v28: o Descriptive Statistics: To summarize the demographic characteristics of the responde nts (frequencies, percentages). o Weighted Mean Analysis: To determine the priority ranking of dimensions and success factors. The weight was calculated based on the relative rating given by each respondent to the set of statements within each dimension. o Gap Analysis: By subtracting the average rating of "Measurability" from the average rating of "Importance" for each dimension, to identify areas with the greatest need for improved measurement tools. o Exploratory Factor Analysis (EFA): To narrow down the numbe r of questionnaire items related to value dimensions and success factors and to examine their underlying structure. The Principal Component Analysis (PCA) method was used with orthogonal Varimax rotation to achieve structural simplicity. Phase 3: Qualitative In-Depth Analysis and Validation through In-Depth Interviews This phase aimed to interpret and explain the quantitative results and refine the initial KPI framework by obtaining detailed insights and practical experiences from experts in the field. – Research Instrument and Sample: Fifteen semi-structured interviews were conducted with high-level experts, deliberately selected based on their outstanding professional track record and leadership role in implementing complex BIM/ISO 19650 projects. The sample consisted of 8 experts from the UK and 7 experts from Saudi Arabia to ensure coverage of the two different contexts (organizational versus strategic).

– Qualitative Data Analysis: The interviews were recorded, transcribed, and then analyzed using Thematic Analysis via NVivo version 14. The analysis followed two main phases: 1. Open Coding: In-depth reading of the transcripts and generation of initial codes describing the main ideas. 2. Pivot Coding: Grouping the initial findings into overarching and interconnected themes (e.g., “Alternative Measures of Intangible Benefits,” “Leadership as a Data Consumer,” “Contextual Flexibility of the Framework”). To enhance the credibility of the results, a member -checking strategy was employed, where summaries of the initial findings were presented to a number of participants for confirmation or correction.

3.2 General Information about Respondents

The final study population (for Phase II) comprised 187 professionals from the United Kingdom (48%) and Saudi Arabia (52%). This balance reflects the effort to understand two distinct contexts driving digital transformation: organizational (UK) and strategic/visionary (Saudi Arabia). As Table 2 illustrates, the sample included key strategic and operational roles within the construction industry, ensuring that the data reflects the perspectives of both decision-makers and implementers.

Table 2. Main functional role of respondents ($n = 187$).

Role	Frequency	Percentage
Project / Construction Manager	52	27.8%
BIM Manager / Coordinator	41	21.9%
Digital Transformation / Innovation Lead	34	18.2%
Commercial Manager / Quantity Surveyor	32	17.1%
Director / Senior Executive (e.g., Operations, Technical)	28	15.0%
Total	**187**	**100.0%**

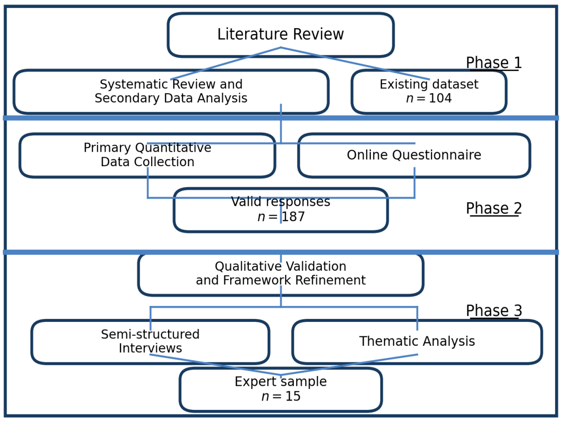

Figure 2. Research methodology flow chart.

n= 104 Phase 1 Phase 2 Phase 3 Literature Review Secondary Data Analysis, Systematic Review Online Questionnaire Primary Quantitative Data Collection N= 150-200 Qualitative Validation and Refinement Thematic analysis Interviews N= 15-20

Integrated Demographic and Professional Profile: – Sector: The role of digital transformation investment in construction is dominated by the private sector (68% of respondents are from this sector) while the public sector accounts for 32% of respondents. This shows that the private sector signifies the majority of businesses that are investing in digital transformation. – Experience: As illustrated in Figure 3, most respondents to the survey have a wealth of construction industry experience, with 71% having 10 or more years’ worth of knowledge and experience within the construction industry and 40% having over 15 years of experience. This demonstrates the depth of knowledge and industry experience behind their responses. – BIM Project Involvement: 83% of respondents indicated high -level involvement and involvement on the stakeholder side of BIM and/or ISO 19650 implementation projects. This supports their responses to the challenges and opportunities related to BIM measuring. – Organization and Project Size: In terms of size, this sample is representative of the group as a wh ole (42% are large organisations (>500 staff), 33% are medium organisations (100 -500 staff), and 25% are small organisations (<100 staff)). A good portion of respondents (38%) typically will undertake large-scale projects (>$50 million) supports the potential for using this framework on a large-scale capital investment projects.

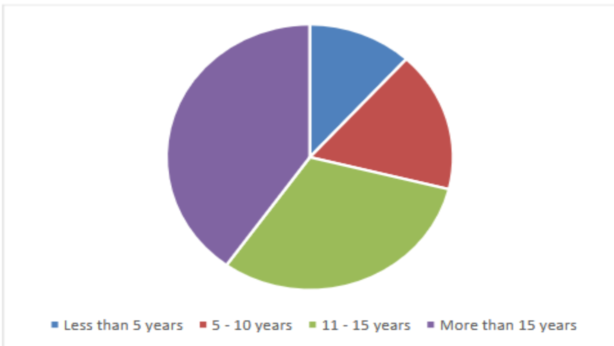

Figure 3. Respondents’ years of experience in the construction industry.

4. RESULTS ANALYSIS

4.1 Questionnaire

4.1.1 Key factors influe\{}ncing BIM Implementation

As shown in Table 3, the analysis of the weighted average results suggests that professionals prioritize concrete, direct factors associated with the delivery of a project. The factor with the highest average ranking was “Operational Efficiency” (average = 4.42), closely followed by “Project Cost Performance” (average = 4.38). The third highest average ranking was for “Strategic Compliance and Risk Mitigation” (average = 4.35) which indicates that there is increasing recognition among professionals about how important it is to ensure compliance with strict regulatory requirements (like the UK Building Safety Act) and how they can help manage high -cost risks (claims and disputes in Saudi Arabia) and thus provide greater strategic value to an organisation .

Table 3. Key value dimensions for measuring return on investment.

Key Value Dimension	Mean	SD	Rank	Trend
Operational Efficiency	4.42	0.78	1	Strongly Agree
Project Cost Performance	4.38	0.81	2	Agree
Strategic Compliance & Risk Mitigation	4.35	0.85	3	Agree
Information Quality & Governance	4.28	0.82	4	Agree
Schedule Performance	4.25	0.87	5	Agree
Organizational & Human Capital	4.10	0.91	6	Agree
Sustainability & Lifecycle Value	3.98	0.94	7	Agree
Weighted Mean (All Dimensions)	4.25	–	–	Agree

As shown in Figure 4, t he results show a consistent and obvious discrepancy, with the perceived level of measurable evidence often falling short of the perceived level of importance across all dimensions measured. There were two major areas where the discrepancy wa s by far the greatest: "Organizational & Human Capital" and "Sustainability & Lifecycle Value." These two areas point directly to a challenge that had previously been emphasized in the literature, namely: the difficulty of measuring intangible long-term value [1].

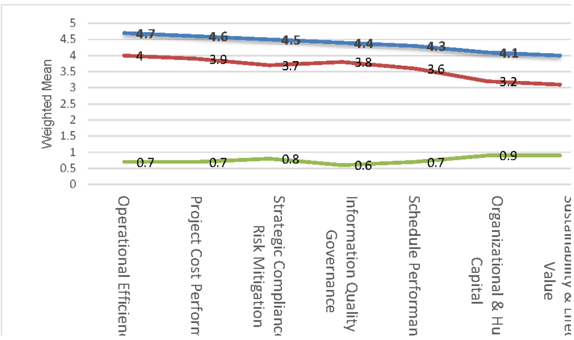

Figure 4. Gap between perceived importance and perceived measurability of value dimensions.

4.1.2 Critical success factors for implementing a measurement system.

In Table 4, the analysis of the Critical Success Factors indicates that Organizational and Strategic Success Factors (OSSF) clearly dominate over Technical Success Factors; Leadership and Care Commitment is ranked higher than all other OSSF with a weighted average of 4.55 and the next ranked success factor is Clear Alignment with Organizational Strategy with a weighted average of 4.48. Thus, these results significantly corroborate the primary research hypothesis — being that the measurement of ISO 19650 earnings is an organization -wide change management and not purely a technical initiative . Additionally, as demonstrated by the ranking of Data Governance and Standardized Processes - ISO 19650 as the third highest ranked success factor (4.40) – it is evident that ISO 19650 is not just Policy and Procedure, but rather is viewed as the infrastr ucture required to provide an effective and trustworthy means for measurement.

Table 4. Critical success factors for implementing the BIM/ISO 19650 KPI system.

Critical Success Factor	Mean	SD	Rank
Leadership Commitment & Sponsorship	4.55	0.72	1
Clear Alignment with Organizational Strategy	4.48	0.75	2
Data Governance & Standardized Processes (ISO 19650)	4.40	0.80	3
Skilled Personnel & Training	4.33	0.82	4
Integration with Existing Systems (e.g., ERP)	4.25	0.85	5
User-Friendly Dashboard & Reporting Tools	4.10	0.88	6

Respondents also indicated that the three biggest obstacles to measuring return on investment currently are: “lack of a standardized methodology” (72%), “difficulty in measuring intangible benefits” (68%), and “fragmen tation of data sources” (65%). The framework developed in this research directly addresses these three obstacles.

4.2 Analysis of qualitative interview results

Interviews with 124 professionals (62 of them are BIM professionals and the other do not use BIM) were arranged to validate the results of the questionnaire. The interviewees suggested mixed approaches to expedite BIM implementation (Top-down and Bottom-up).

4.2.1 Verifying the dimensions and mechanisms for addressing challenges

All the experts a ffirmed the validity and importance of the seven dimensions identified by the survey, but they expanded upon them with crucial practical insights. Here are some examples: Experts reported that the outcome indicator(s) of an information request’s quantity m ust be connected to process indicator(s) related to average cycle time(s) from when an issue is presented or created and the response to that issue. This helps demonstrate where the most value from shared data environments is derived. For example, experts in the United Kingdom connected this aspect to the Building Safety Act’s mandate regarding a "gold thread of information." As a result, Key Performance Indicators (KPIs) associated with the gold thread of information should demonstrate success or progress made within the context of leadership development and additional universe (UK) focus on sharing information. Similarly, experts in Saudi Arabia connected this aspect with conflict resolution and, as such, provided additional quantitative indicators of succ ess or progress made in addressing information -related errors, such as total cost attributed to claims arising out of information errors. Additionally, addressing the challenge of measuring intangible dimensions of related work continues to be an ongoing discussion point among experts. As such, many propose using "practical proxy metrics." For instance, one expert stated that "we know good leadership makes things work, but there’s no way to put a number on improved collaboration. What we can do is use proxy metrics such as efficiency and effectiveness indicators of model coordination meetings."

4.2.2 Integration between leadership and operation

Through the interviews, it became evident that we gained a more in-depth qualitative perspective regarding the first critical success factor (leadership). It became apparent during the interviews that leadership does not play a passive role as a supporter, but instead functions as the "primary and active consumer" of the key performance indicator (KPI) system. In othe r words, experts indicated that the effectiveness of the KPI system occurs only when leaders (i.e., those at the highest level of management) regularly seek out the information provided by the KPI system and use that data to assist in the decision-making process. Moreover, experts further elaborated on the fact that the ISO 19650 standard creates a "necessary accelerator" that creates a level of data discipline such that measuring indicators like "information quality" becomes an actionable and meaningful ac tivity.

4.2.3 Proposed tiered framework for key performance indicators

Based on a synthesis of all quantitative and qualitative insights, a phased and integrated operational framework was developed, as illustrated in Table 5. This framework represents an evolutionary path to measurement, where the guiding indicators at levels 1 and 2 establish the foundation for achieving and measuring the lagging indicators at level 3, while level 4 monitors the regulatory factors that support long-term sustainability.

Table 5. Proposed tiered structure for an integrated KPI framework.

KPI Tier	Purpose (Type)	Example Metrics	Suggested Data Source
Tier 1: Foundation (Leading)	To measure the adoption and health of core ISO 19650 processes.	CDE usage rate; BEP compliance score; model validation pass rate.	Automatic CDE logs; periodic audit reports.
Tier 2: Operational Performance (Leading)	To measure the efficiency and quality of real-time delivery processes.	RFI cycle time; clash detection density and resolution rate; Design Maturity Index.	CDE platforms; project management software; clash detection tool reports.
Tier 3: Financial & Strategic Outcomes (Lagging)	To measure the tangible impact on project and business performance.	Cost of rework; cost variance; reduced disputes; bid win rate for digital projects.	Financial systems; accounting and cost records; commercial and legal records.
Tier 4: Organizational Health (Leading)	To measure supportive capabilities and transformation culture.	Digital competency index; staff engagement with digital tools; leadership support score.	Employee surveys; training completion records; 360-degree feedback.

4.2.4 Synthesis of results and formulation of the model and hypotheses

Using this comprehensive analysis as the basis for developing an integrated and comprehensive sequential conceptual model, the authors developed a comprehensive explanation for how an organization can achieve measurable value through the adoption of ISO 19650 standards. A summary of this comprehensive analysis is presented in Figure 5. As part of this sequential conceptual model, it is presumed that the primary catalysts driving organizational success in adopting ISO 19650 processes are the motivation of organizational leadership and effective management of transformational change. Through successful adoption, organizations can create a unified digital data foundation (or shared digital environment) that serves as the basis for procuring consistent and complete information to support the implementation of a tiered KPIs framework. With this unified sy stem of digital data, organizations are empowered to visually identify and report on data-driven proactive decisions made using their digital data, ultimately providing organizations with quantifiable ROI and sustainable strategic value identified as the quantifiable 'ISO 19650 dividend'.

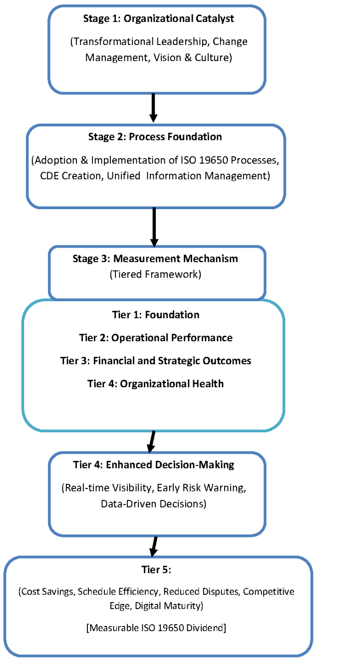

Figure 5. Sequential conceptual model for achieving measurable "ISO 19650 earnings.

Stage 1: Organizational Catalyst (Transformational Leadership, Change Management, Vision & Culture) Tier 1: Foundation Tier 2: Operational Performance Tier 3: Financial and Strategic Outcomes Tier 4: Organizational Health Tier 4: Enhanced Decision-Making (Real-time Visibility, Early Risk Warning, Data-Driven Decisions)

Tier 5: (Cost Savings, Schedule Efficiency, Reduced Disputes, Competitive Edge, Digital Maturity) [Measurable ISO 19650 Dividend] Stage 2: Process Foundation (Adoption & Implementation of ISO 19650 Processes, CDE Creation, Unified Information Management) Stage 3: Measurement Mechanism (Tiered Framework)

5. DEVELOPING THE HYPOTHESES

To test the relationships within this model and the applicability of its framework empirically in future research phases, the following hypotheses were formulated: 1. Hypothesis H1: There is a statistically significant positive relationship between the maturity level of ISO 19650 processes in an organization and the accuracy and usefulness (decision validity) of the key performance indicators (KPIs) extracted from its project data. 2. Hypothesis H2: Adopting a hybrid leadership style (containing transformational, participative, and prescriptive elements) during the implementation of a KPI system leads to higher levels of data accuracy and user engagement compared to single-leadership styles. 3. Hypothesis H3: A tiered framework that integrates prescriptive (levels 1, 2, and 4) and lagging (level 3) indicators is rated by construction industry practitioners as more applicable and effective in measuring overall ROI compared to frameworks that focus solely on lagging financial indicators.

6. MODEL VALIDATION

6.1 Results of quantitative verification via survey:

Validating the conceptual model (Figure 6) and testing the hypotheses (H1 -H3) required advanced statistical analysis of the survey data ($n = 187$). Regression and path analysis techniques were used to ve rify the proposed causal relationships. Figure 9 shows the relative strength of the effect for each path in the m odel, represented by standard path coefficients (β), which were obtained through path analysis using AMOS v28. All coefficients indicate statistically significant positive relationships ($p < 0.05$).

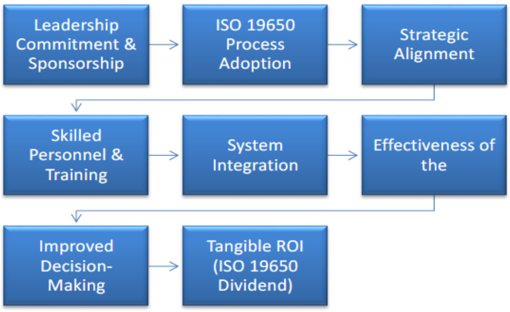

Figure 6. Results of path analysis of relationships between variables in the conceptual model.

6.2 Interpretation of Results and Hypothesis Testing:

Hypothesis H1 (Accepted): The results showed a strong and statistically significant positive relationship ($\beta = 0.81$, $p < 0.001$) between "adoption of ISO 19650 processes" and "effectiveness of the KPI framework." This indicates that the maturity of standard processes is a prerequisite for extracting accurate and meaningful KPI data. Hypothesis H2 (Partially Accepted): While "hybrid leadership styles" (measured as a composite variable) showed a positive effect on data accuracy and user engagement, this effect was indirect and occurred primarily through Leadership Commitment & Sponsorship ISO 19650 Process Adoption Strategic Alignment Skilled Personnel & Training System Integration Effectiveness of the Improved Decision- Making Tangible ROI (ISO 19650 Dividend)

its promotion of process adoption ($\beta = 0.72$) and improvement of staff quality ($\beta = 0.65$). Its direct effect on the KPI system alone was not statistically significant. Hypothesis H3 (Accepted): The applicability and effectiveness of the "scalarized framework" (compared to the traditional financial framework) were measured by practitioners' ratings of its usefulness in decision -making. Analysis of variance (ANOVA) showed a statistically significant difference ($F(1,185) = 24.36$, $p<0.001$) in favor of the graded framework in improving proactive project visibility and decision quality.

6.3 Qualitative Verification and Refining via Interviews

As shown in table 6, the opinions of the 15 experts deepened the qualitative understanding of the model's workings and added critical nuances for practical application.

All experts agreed upon the logical order of stages of the 5 Stage Model. Some experts, however, recommended an

Table 6. Ranking of variables impacting BIM implementation.

Critical Factor	Freq.	Rank	Contextual Nuances
Leadership as the "Data Consumer"	15	1	Managers create transformation when they request dashboard indicators rather than static reports.
ISO 19650 Adoption as an "Essential Enabler"	14	2	ISO 19650 ensures measured information is correct and reliable by standardising naming, delivery, and information quality.
Contextual Flexibility of the Tiered Framework	12	3	In Saudi government projects, organisations may begin with outcome indicators, then return to foundation tiers.
Proxy Metrics for Intangible Benefits	11	4	Supplier engagement in updating the CDE can act as a proxy for supply-chain collaboration strength.

important modification. Rather than just a linear approach, it should be seen as an iterative cycle back to earlier stages, especially when progressing from Stage 4 Improving Decision -Making to Stage 1 Organizational Motivation. An example of this is described by one expert: "When small, measurable savings are made, it promotes creating a culture of data and supporting leadership (Stage 1) which in turn feeds back into the process of investing in processes (Stage 2). This creates a continual cycle or upward spiral rather than a linear path." Based on this integrative view of quantitative and qualitative analysis, the final, revised model for implementing the framework was developed, as illustrated in Figure 7, which embodies both the logical sequence and the iterative, cyclical nature of the value realization journey.

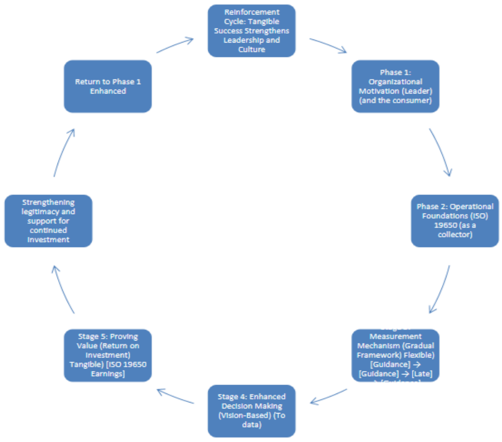

Figure 7. Ultimate integrated model for achieving ISO 19650 profitability.

7. CONCLUSION

This paper unambiguously establishes that the greatest impediment to the extensive digital transformation of the construction industry is actually the internal structure and rules more than the technology itself. On the one hand, past research has showcased how BIM and ISO 19650 Transformations benefit the industry, on the other, it has always been difficult to put a number on the return of investment (ROI) in these cases. Our key breakthrough here is to close this space by offering a pragmatic, tiered KPI framework. Such a tool empowers companies not only to abandon paper evidence but at the same time to assess their effectiveness through the dual lenses of process integrity and financial paybacks. Reinforcement Cycle: Tangible Success Strengthens Leadership and Culture Phase 1: Organizational Motivation (Leader) (and the consumer) Phase 2: Operational Foundations (ISO) 19650 (as a collector) Stage 3: Measurement Mechanism

(Gradual Framework) Flexible) [Guidance] → [Guidance] → [Late] → [Guidance] Stage 4: Enhanced Decision Making (Vision-Based) (To data) Stage 5: Proving Value (Return on Investment) Tangible) [ISO 19650 Earnings] Strengthening legitimacy and support for continued investment Return to Phase 1 Enhanced

The main original idea is combining and extending the research in different fields. We routed the studies of data, driven decision frameworks, leadership roles, and change management. Our research shows that consistent high, performance leadership and change management are the main driving forces when an organization is allowed to build the ISO 19650, compliant operating basis for measurement. This basis is not the goal but rather the indispensable launching pad for our multi, level KPI framework. Our multi, level KPI framework systematically connects the daily operational activities at the shop floor and operational management levels (Tiers 1 & 2) with the strategic and financial outcomes (Tier 3), thus giving the management a diagnostic tool to both support and evidence value demonstration, which in turn leads to the comprehensive measurement of the leading and lagging indicators. A fundamental newidea tackles the problem of quantifying those non, material benefits, like better teamwork or less risk, which can be very hard to express in numbers. We present a systematic way of going about this, by working with "alternative metrics" and a "value, defining matrix", to lay down these intangible benefits in a stepwise, measurable manner that makes sense. By way of example, collaboratio n improvement can be monitored by a metric such as the number of meetings, which in turn impacts the time for conflict resolution, the final stage being change of costs for rework. With this method, the company is able to demonstrate these intangible improvements and builds an evidence, based culture. Most importantly, the quantified 'ISO 19650 Dividend' is not something that can be obtained only from software or policy. It results from a sequential and iterative process that starts with committed leadershi p, moves through setting up standardized processes, and ends in a culture of systematic measurement that transparently connects effort to outcome. By combining qualitative and quantitative methods, and utilizing data from the very different environments of the UK and Saudi Arabia, our research gains validity and deepens the practical framework development. Nevertheless, the use of this framework must reflect the limitations of the study. The geographic coverage, although deliberately comparative, indicates that the results should be adjusted to the local regulatory, economic, and cultural value systems in different places. On the methodological side, difficulties in obtaining confidential project financial data resulted in the use of expert opinions and proxy metrics; these, although valuable, cannot fully substitute precise accounting. Moreover, the intentional selection of seasoned professionals might restrict the extent to which the views of smaller or less digitally mature organizations can be generalized . Besides, the framework's ability to predict ROI and the generally accepted sequential logic from leadership to value realization are aspects that need to be confirmed through longitudinal case studies, which are an essential channel for future research. However, in spite of those limitations, here the study provides a solid, practical base for turning digital transformation in construction into a transparent, accountable, and value, based investment.

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