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DETERMINING DIGITAL LEADERSHIP FACTOR IN THE CONSTRUCTION INDUSTRY: A COMPONENT ANALYSIS OF INTERNAL & EXTERNAL ASPECTS

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Abstract:

Notion of Construction IR 4.0 has evolved recently, managers have to deal with increasingly difficult decision-making processes. The present study aimed to bridge this gap by employing the TAM and EOT theories and synthesising extant research to generate an exhaustive inventory of 16 crucial digital leadership factors (DLFs) for leader and organisation, respectively, which were assessed by 341 construction managers. The data were ranked using factor analysis following a relative relevance index. The information indicates that internal aspects fall into three cluster: (1) factors related to digital strategy and expertise, (2) commitment and trust, and (3) digital literacy and skill acquisition. Three clusters of external aspects were identified: (1) factors related to collaboration and partnerships; (2) factors related to digital cybersecurity and policy; and (3) factors related to capital, workshops, and training. Thus, efforts to enhance digital leadership practice (DLP) in Malaysia ought to concentrate on these wide groups.

Keywords:

Construction IR 4.0; Critical Success Factor; Digital Leadership Practice; Digital Innovation

Introduction

Construction industry is viewed as a difficult yet vital on a global scale because of the services sector's nature and uncertainties in technology, design, engineering, operations, maintenance, location, and other environmental variables. The building of process plants is particularly complex (Simanjuntak, 2021; Chen et al., 2022). The construction firm bears primary responsibility for project implementation and supply of necessary material, labour, and financial resources. According to Wang et al., (2022) within three years, the global construction market will reach the record level of 15 trillion dollars and will continue to grow at a yearly rate of around 3% through to 2025. Given how quickly digital technology (DT) is developing, forward-thinking leadership is the potential attributes to create a purposeful and distinct vision for the decision-making processes of digital strategies to execute (Stana et al., 2020). Generally, it is a social transformation process where advanced information technology acts as a mediator to influence the behaviour, attitudes, emotions, thoughts, behaviours then to the organization (Hensellek, 2020) as in construction organization. The broad term of “digital leadership” has been used in the twenty-first century, as this term may also be striking contrasts between traditional leadership and leadership in the digital era since they primarily result in a changing workplace where technology interaction is crucial (Phelps, 2014; Shahadat et al., 2023). Furthermore, the move to digitalization from a legacy perspective and increased corporate integration of information technology (IT) and business innovation in the new era of business IT emphasis the need for digital proficiency (Alaboud & Alshahrani, 2023). The term “digitalisation” refers to improve and modify organization processes by utilising DT to link people, devices, and data (Aghimien et al., 2022), which a crucial capability for leaders as a vital role in decision-making processes. Therefore, the term seems to emphasize a fundamental change in how firms approach their work and respond to digital trends in a cutthroat market (Sasmoko et al., 2019).

To assist managers, navigate the digital adolescence, conceptualizing digitalization should be viewed as a continual process for growth and development. The construction industry deals with a variety of internal and external issues and influences that may either favourably or adversely affect the successful execution of the managing (Milosevic, 2010). Due to variations in political economies, legal systems, and cultures, these characteristics change between nations. In Malaysia, a government supported and provide a training called Certified Construction Manager (CCM) by CIDB attempt to encourage collaboration between quality management and the business environment in an effort to meet client demands and produce a construction project that is physically functional, finished within the allotted time frame, and adheres to predetermined criteria for quality, cost, and other factors (Farhan Roslan et al., 2021; Nurafizah Amiruddin, 2019). However, notwithstanding such attempt, the programme did not receive an encouraging response due to a lack of strong awareness among construction stakeholders. Aghimien et al., (2020) discovered that fear of increased investment costs, the absence of a local green certification, a lack of government backing or legislation, and a lack of financial incentives are some of the key issues in facing digitalization by leader and subordinate. There are a number of other barriers to DLP in Malaysia, such as laws or legal restrictions, building codes, public awareness campaigns, the creation of regulatory systems, and client demand (Abbu et al., 2020; Ann Prince, 2018; Martins, 2019; Shahadat et al., 2023).

Very few studies have highlighted the critical success factor to become digital leaders in construction industry causing a paucity of information on the subject (Leyh et al., 2021), as a result, very little information to help stakeholders and researchers understand issues related to

digital resilience. This study examined crucial internal and external aspects to the digital leaders characteristic in Malaysia's construction industry, considering the paucity of previous research and the significance of DLP. This is significant because, although the rest of the globe is creating cutting-edge DT solutions, Malaysia, in particular, is still having difficulty putting established technological principles into practice. There is empirical data to support this, as well as suggestions for solutions. In order to determine the underlying structure of the items, this study first identified and evaluated items from literature that were said to be both internal and external to the digital leadership factors (DLFs). The most significant items within each category were then determined by ranking the items within each category.

Literature Review and Research Methodology

In order to determine the internal and external digital leader variables that contribute to the digital resilience of the construction industry, the study began with a review of the literature. Table 1 and Table 2 present the literature sources for the criteria that were identified and subsequently developed into self-completing questionnaire items while the results are displayed in Table 4 and Table 5. To make sure the questions were relevant and logical, a pilot test and review were conducted on the questionnaire items. Following a pre-test, exploratory factor analysis, reliability and validity testing, certain items underwent minor revisions. Using a five-point Likert scale, respondents were asked to rank how much they agreed with each of the DLFs (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree). The adoption of the five-point Likert scale was motivated by its capacity to yield results that are clear and simple to understand (Jebb et al., 2021).

Table 1: Consolidated List Of Internal Aspects Of Digital Leadership Factors

Code	Internal Aspects	Key Reference
COM1	Perceptions, thoughts and ideologies are high about digitization.	Abbu et al., 2020; Hewavitharana et al., 2021; Maruthuvellu et al., 2021; Yang et al., 2022
COM2	Leader have a good knowledge of the needs and use of the latest digital technologies.	Abbu et al., 2020; Ismail & Hassan, 2019; Maruthuvellu et al., 2021; Tadesse Gebretekle et al., 2021; Yang et al., 2022
COM3	Leader concerned about the issue of coordination and use of digital technology in the organization.	Abbu et al., 2020; Imran et al., 2020; Maruthuvellu et al., 2021; Yang et al., 2022; S. L. Zulu et al., 2023
COM4	Leader are able to guide subordinates to implement the adoption of new technologies.	Abbu et al., 2020; Maruthuvellu et al., 2021; Schiuma et al., 2022; Yang et al., 2022; S. L. Zulu et al., 2023
COM5	Leader easily understand the use of existing / new digital technology. <i>Exp: Microsoft project, BIM, Revit.</i>	Abbu et al., 2020; Aghimien et al., 2022; Imran et al., 2020; Maruthuvellu et al., 2021; Yang et al., 2022
COM6	Leader have high skills in problem solving especially in digital technology.	Abbu et al., 2020; Avirag Bajpai & Subhas Chandra Misra, 2020; Maruthuvellu et al., 2021; Yang et al., 2022
COM7	Leader show interest to subordinates requirement and views on an issue.	Abbu et al., 2020; Aghimien et al., 2020; Maruthuvellu et al., 2021; Yang et al., 2022
COM8	Leader contributes ideas in the management of the organization digitally.	Abbu et al., 2020; Maruthuvellu et al., 2021; Yang et al., 2022
CAP1	Issue of implementing and using digital technologies often discussed at meetings.	Abbu et al., 2020; Maruthuvellu et al., 2021; Shirokova et al., 2020; Yang et al., 2022)

CAP2	Leader invest funding for programs and strategic requirements for the use of technology in organizations.	Abbu et al., 2020; Chuey et al., 2021; Gudergan et al., 2021; Maruthuvellu et al., 2021; Yang et al., 2022
CAP3	Leader insight to increase the use of digital technology in organization.	Abbu et al., 2020; Maruthuvellu et al., 2021; Petrov et al., 2021; Wernicke et al., 2021; Yang et al., 2022
CAP4	Leader committed implement new ways of working digitally in the company's organization.	Abbu et al., 2020; Maruthuvellu et al., 2021; Yang et al., 2022; S. Zulu, 2022; S. L. Zulu et al., 2023
CAP5	Reduce non-interested job positions such as clerks and to provide technology management job positions.	Abbu et al., 2020; Gudergan et al., 2021; Jacobsson & Linderoth, 2021; Maruthuvellu et al., 2021; Yang et al., 2022
CAP6	Leader regularly attend programs that engage with construction technology management.	Abbu et al., 2020; Maruthuvellu et al., 2021; Tadesse Gebretekla et al., 2021; Yang et al., 2022
CAP7	Leader conveys information through diverse communication channels directly to the management hierarchy.	Abbu et al., 2020; Maruthuvellu et al., 2021; Tadesse Gebretekla et al., 2021; Yang et al., 2022
CAP8	Leaders prefer to receive client information, sub-contractors, suppliers digitally.	Abbu et al., 2020; Imran et al., 2020; Maruthuvellu et al., 2021; Schiuma et al., 2022; Yang et al., 2022; S. L. Zulu et al., 2023

From the websites of the Construction Industry Development Board (CIDB), Board of Quantity Surveyors (BQSM), Board of Architects (BOA), and Board of Engineers Malaysia (BEM), we were able to identify the respondents based on their membership in their respective professional and statutory registration bodies such as project and construction managers, quantity surveyors, architects, and engineers (mechanical, electrical, and civil), were given the questionnaire. Research on the use of digital technologies in the construction industry has made extensive use of this methodology (Alaboud & Alshahrani, 2023; Jahanger et al., 2022; Shahadat et al., 2023). The nonprobability convenient sampling approach was selected because, in the wake of the COVID-19 health epidemic, it offered a workable remote online data gathering platform that was secure and practical. During this time, online data collection techniques have been proven to be non-intrusive, secure, entertaining, and practical (Chuey et al., 2021).

Table 2: Consolidated List Of External Aspects Of Digital Leadership Factors

Code	External Aspects	Key Reference
SRU1	The management provides the needs for the use of digital technology in the organization.	Alaboud & Alshahrani, 2023; Morgan, 2019; Shahadat et al., 2023; Sinenko et al., 2021; Srivastava et al., 2021
SRU2	The management provides skills training in the handling of new technologies to subordinates.	Alshehhi et al., 2023; Konopik et al., 2022; Morgan, 2019; Sinenko et al., 2021; Srivastava et al., 2021
SRU3	Cooperation from clients, sub-contractors, suppliers in the use of technology that is parallel in facilitating online management.	Alshehhi et al., 2023; Morgan, 2019; Schwarzmüller et al., 2018; Sinenko et al., 2021; Srivastava et al., 2021
SRU4	The management shares resources with the consultant to increase the specialization of materials. <i>Exp: Online payment</i>	Alshehhi et al., 2023; Konopik et al., 2022; Morgan, 2019; Sinenko et al., 2021; Srivastava et al., 2021; Tadesse Gebretekla et al., 2021

SRU5	The application of digital asset management in my organization is very effective and efficient.	Alshehhi et al., 2023; Morgan, 2019; Shahadat et al., 2023; Sinenko et al., 2021; Srivastava et al., 2021
SRU6	The management of digital asset management in my organization is very well organized.	Alshehhi et al., 2023; Morgan, 2019; Shahadat et al., 2023; Sinenko et al., 2021; Srivastava et al., 2021
SRU7	Incentives from the company's profits to increase the resources of digital technology.	Alshehhi et al., 2023; Morgan, 2019; Sinenko et al., 2021; Srivastava et al., 2021; Zhu et al., 2022
SRU8	Management's willingness to invest capital in digital competency programs and training to subordinate.	Alshehhi et al., 2023; Morgan, 2019; Aghimien et al., 2022; Diana et al., 2019; Shirokova et al., 2020
STA1	The management strives to enhance the use of new technologies and new equipment.	Alshehhi et al., 2023; Konopik et al., 2022; Morgan, 2019; Sinenko et al., 2021; Srivastava et al., 2021
STA2	Disclosure of initiatives from government, Roadmap Construction 4.0 galvanizing existing digital assets resources.	Alshehhi et al., 2023; Moeuf et al., 2020; Morgan, 2019; Sinenko et al., 2021; Srivastava et al., 2021
STA3	Obtaining government support in providing funds to employers in promoting the use of technology.	Alshehhi et al., 2023; Diana et al., 2019; Morgan, 2019; Sinenko et al., 2021; Srivastava et al., 2021
STA4	Getting government support in the provision of grants/funds to upgrade new technology facilities.	Alshehhi et al., 2023; Diana et al., 2019; Moeuf et al., 2020; Morgan, 2019; Sinenko et al., 2021
STA5	The company's information security is preserved and securely stored in cloud storage.	Alshehhi et al., 2023; Moeuf et al., 2020; Morgan, 2019; Sinenko et al., 2021; Srivastava et al., 2021
STA6	Policies and laws involving the use of digital technologies are clear.	Shahadat et al., 2023; Shirokova et al., 2020; Sinenko et al., 2021; Srivastava et al., 2021; Tadesse Gebretekle et al., 2021
STA7	Management of 'tendering' contracts and payments to third parties through E-contracts.	Avirag Bajpai & Subhas Chandra Misra, 2020; Morgan, 2019; Sinenko et al., 2021; Srivastava et al., 2021
STA8	The vision/mission of the company that implements the development of management digitally.	Alshehhi et al., 2023; Mhlungu et al., 2019; Morgan, 2019; Sinenko et al., 2021; Srivastava et al., 2021

There are two phases of data analysis were carried out. Initially, the internal and external DLFs cluster included in the questionnaire were determined through the use of Exploratory Factor Analysis (EFA). In order to find fewer factors that best capture the structure of relationships, factor analysis is performed to determine the underlying structure or patterns among the variables. Establishing the factorability of the scales, figuring out how many factors there were, and assessing the dependability of each factor as a gauge of internal consistency were all part of the EFA process (Costello & Osborne, 2005; Shrestha, 2021; Watkins, 2018). Next, the conditions of the data were observed using frequency and descriptive statistics through the Relative Importance Index (RII) by weighting that each respondent provided on a scale of one to five the most (Johnson & LeBreton, 2004). Each variable's relative relevance index was determined, and overall rankings were set for each variable and each cluster that resulted from EFA meanwhile arranged from highest to lowest in descending order with five significant levels; low (L) ($0 \leq RI \leq 0.2$), medium-low (M-L) ($0.2 \leq RII \leq 0.4$), medium (M) ($0.4 \leq RII \leq$

0.6), high-medium (H–M) ($0.6 \leq RII \leq 0.8$) and high (H) ($0.8 \leq RII \leq 1$), which were inferred from the RII scores (Shrestha, 2021).

Data Analysis and Findings

The demographic details of 341 sample's respondents are shown in Table 3 where 39.88% of the workforce was employed by contractor firms, 7.04% by government departments or local authorities, and the other individuals were categorised as other (freelancers, academicians). Majority of the respondents (55.42%) from the middle management position which is construction and project managers, executive manager, project engineers, (25.22%) from upper management in position of proprietor (founder), construction and project directors while (19.35%) from the frontline management position which is site supervisor, site safety officer and superintendent. Most respondents had at least 3 years of experience (39.58%) while 9.38% had more than 15 years' experience in construction industry.

Table 3: Respondent's Demographics

Organization Type	Frequency	Percentage (%)
Developer	56	16.42
Consultant	72	21.11
Contractor (SMEs/ Big Firm)	136	39.88
Local Authority	24	7.04
Suppliers	14	4.11
Others	39	11.43
Management Position	Frequency	Percentage (%)
Top Management	86	25.22
Supervisory Management	189	55.42
Frontline Management	66	19.35
Years of Experience	Frequency	Percentage (%)
Less than 3 years	135	39.58
3 to 5 years	80	23.46
6 to 10 years	64	18.76
11 to 15 years	30	8.79
More than 15 years	32	9.38

Exploratory Factor Analysis

A few numbers of factors that best reflected the pattern of links between the collection of variables for both the internal and external DLFs cluster were found using factor analysis (Watkins, 2018). In this sense, the EFA was carried out using primary axis factoring with varimax rotation. According to Hair et al. (2010), the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy must be above 0.7, the Bartlett' Test of Sphericity (BTS) must be significant at $p < .05$, and all communalities must be above 0.3. Additionally, determining factorability involves determining if the items in the same scales are correlated to a factor of at least 0.3 with another item.

Table 4: Relative Importance Index Ranking Of Internal DLF

Internal aspects	Factor Scores			Cronbach's alpha	RII	Overall Rank	Important Level
	1	2	3				
Digital Literacy & Skill Acquisition				0.883			
COM5	0.576				0.747	8	H-M
COM1	0.754				0.673	13	H-M

COM6	0.829		0.660	14	H-M
COM3	0.720		0.639	15	H-M
COM4	0.757		0.565	16	H-M
Digital Strategy & Expertise		0.834			
CAP6	0.703		0.870	1	H
CAP5	0.659		0.853	2	H
CAP1	0.675		0.830	3	H
COM2	0.510		0.781	5	H-M
COM7	0.516		0.772	6	H-M
CAP2*	0.496		0.753	7	H-M
COM8	0.512		0.742	10	H-M
Commitment & trust to transform		0.649			
CAP4		0.669	0.799	4	H-M
CAP7*		0.480	0.745	9	H-M
CAP3		0.509	0.709	11	H-M
CAP8		0.597	0.680	12	H-M

*Excluded from analysis (factor loading < 0.5)

Note: The full description for the internal aspects codes are shown in Table 1.

The findings showed general factorability for the external and internal DLFs, with KMO values for barriers (0.856) and internal (0.894) significantly higher than the lowest advised threshold. Each of the two had substantial BTS values ($p < 0.001$), and every communality was more than 0.3. For both barriers and drives, a minimum Eigenvalue of one (1) was used to determine the number of underlying components. With explained variances of 72.7% (Table 4) and 63.7% (Table 5), respectively, three factor solutions were retrieved for both the internal and external DLFs, above the required minimum value of 60% (Shrestha, 2021). Both the internal and exterior DLFs factor loading were more than 0.5. According to Costello & Osborne, (2005); Shrestha, (2021); Watkins, (2018), all of the Cronbach's alpha values (α) were greater than 0.7, indicating the reliability of the established underlying themes.

Table 5: Relative Importance Index Ranking Of External DLF

External aspects	Factor Scores			Cronbach's alpha	RII	Overall Rank	Important Level
	1	2	3				
Collaboration & Partnering				0.856			
SRU8	0.696				0.869	1	H
SRU1	0.750				0.855	2	H
SRU5	0.578				0.849	4	H
SRU3	0.635				0.808	6	H
SRU4	0.681				0.788	7	H-M
SRU6*	0.482				0.787	8	H-M
SRU7	0.518				0.781	9	H-M
STA1	0.529				0.751	12	H-M
Digital Cybersecurity & Policy				0.781			
STA8		0.593			0.853	3	H
STA5		0.600			0.830	5	H
STA6		0.616			0.753	11	H-M
STA4*		0.473			0.742	13	H-M
Capital, Workshop & Training				0.807			
STA3			0.637		0.772	10	H-M
SRU2			0.528		0.738	14	H-M
STA2			0.807		0.673	15	H-M

STA7	0.765	0.660	16	H-M
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*Excluded from analysis (factor loading < 0.5)

Note: The full description for the external aspects codes are shown in Table 2.

The three components for internal DLFs were determined to reflect (1) digital literacy and skill acquisition factor, (2) digital strategy and expertise factors, and (3) commitment and trust factors after a study of the established component structure in accordance with existing research. For external DLFs were termed as (1) collaboration and partnering factors, (2) digital cybersecurity and policy factors and (3) capital, workshop and training factors. The factors found were mostly comparable to those found in the body of existing literature (Tagscherer & Carbon, 2023).

Relative Importance Index (RII)

Internal Aspects Of Leadership Capability

With the exception of one, all of the digital strategy and expertise factors achieved a high relevance level ($RII > 0.8$), giving them the highest overall ranking. The variable with the highest ranking inside this cluster was participating competency program ($RII = 0.870$) followed by provide data analytics position ($RII = 0.853$) and DT issue discussed in meeting regularly ($RII = 0.830$). The remaining variables of virtual data information adoption ($RII = 0.781$), acknowledge the viewpoints of subordinates ($RII = 0.772$) and contributes concepts via digital ($RII = 0.742$), were all ranked high-medium. Among the commitment and trust factor, all the variable with devoted to taking the lead ($RII = 0.799$) followed by towards reliance visionaries ($RII = 0.709$) and availability to trust third-parties digitally ($RII = 0.680$), were all ranked high-medium. All of the variables were ranked high-medium in terms of the digital literacy and skill acquisition factor. The most important item was awareness of the existing DT ($RII = 0.747$), followed by digital mindset ($RII = 0.673$), digital skillset ($RII = 0.660$), emphasise the demand for DT ($RII = 0.639$), and navigate DT implementation ($RII = 0.565$). Table 4 shows the results of the factor analysis and relative important index for the internal aspects of digital leadership practice in the Malaysian construction industry.

External Aspects Of Organization Capability

Collaboration and partnering factor were ranked highly as the external factor of digital leadership in construction organization. Specifically, the capital dispense for DT sources ($RII = 0.869$) was identified as the main impediment to the adoption of DT in the construction sector. The next important variable were upgrade latest DT sources ($RII = 0.855$), structured digital asset management DAM ($RII = 0.849$) and digital-based joint ventures ($RII = 0.808$). The remaining available of integration of information resources with consultant ($RII = 0.788$), investment to technology development ($RII = 0.781$) and culture of sharing best digital practices ($RII = 0.751$). For digital policy and cybersecurity factor required digital vision and mission ($RII = 0.853$) followed by security cloud information trust ($RII = 0.830$) had a high importance ranking while policies and regulation initiative ($RII = 0.753$), are ranked high-medium. All capital, workshop and training factor were ranked high-medium with government financial incentives ($RII = 0.772$), subordinate digital training and workshop ($RII = 0.738$), availability of IR 4.0 construction services ($RII = 0.673$) and fostering e-contract ecosystem ($RII = 0.660$). Table 5 shows the relative relevance index and factor analysis results for the external factor of digital leadership practices in the Malaysian construction industry.

Discussion

Many sectors' research used a number of theories to analyse the internal and external aspects of digital leadership practices, including Diffusion Innovation (DOI) (Alyoubi & Yamin, 2021), Unified theory of acceptance and use of technology (UTAUT) (Hewavitharana et al., 2021), Theory Planning Behaviour (TPB) (Jimmieson et al., 2008), Resource Based View (RBV) (Sarjana, 2017), Technology Adaption Model (TAM) (Aziz et al., 2020), Theory of Reasoned Action (TRA) (Ng, 2020) and Technology-Organization-Environment (TOE) (Chong & Olesen, 2017). This study more focusing on the individual which managerial mindset and skillset perspective, value creation as it account for the organization as well as the environment towards DT adoption. Therefore, literature were identified through TAM theory that influence internal aspects for leadership capability that produced three underlying constructs from factor analysis and these are (1) digital literacy and skill acquisition factors, (2) digital strategy and expertise factors and, (3) commitment and trust factors. Meanwhile, TOE theory implemented in external aspects for organization capability through factor analysis construct (1) collaboration and partnering factors, (2) digital cybersecurity and policy factors and (3) capital, workshop and training factors. Both gives crucial success factor to form business innovation strategy to ensure the construction organization orientation aligns with the forward-thinking digital leaders towards Construction Roadmap IR 4.0 (Cavaleri & Reed, 2008; Nurafizah Amiruddin, 2019).

TAM theory is important for leader intention which an ability to adapt with perceived usefulness and perceived ease to use by the transformation of regular resources already in place, decision-making processes, products and services as a part of the new capability (Aziz et al., 2020; Warner & Wäger, 2019). Capability for leadership focuses on the competency and capacity source of how to build, expand, and alter an organisation to accommodate changes, all the way up to establishing a brand-new paradigm for transformation (Čirjevskis, 2019; Sasmoko et al., 2019). Integrating forward-thinking executives and rearranging the organization's capabilities as a part of awareness, realising, and ongoing transformation can accomplish a transformation (S. L. Zulu & Khosrowshahi, 2021). The development of leadership capability consists of competency (COM1 – COM8) and capacity (CAP1 – CAP8) as mention in literature (Abbu et al., 2020; Maruthuvellu et al., 2021).

The ability of subordinates to adapt, manage, or organise with internal and external shifts by rebuilding the current exercise, sources, goods, and services as a component of new capability in a rigid organisation is defined as a narrative impact organisation capability provided by the integration with TOE theory (Chong & Olesen, 2017). In order to learn how to construct the newest platform by incorporating, redesigning, getting, and absolving capital, company innovation is being created as an external mechanism (Shahadat et al., 2023; Shirokova et al., 2020; Tadesse Gebretekla et al., 2021; Zhu et al., 2022). To create prospects for the firm's development, organisational structure (STU1–STU8) and strategy (STA1–STA8) are tied to subordinates, local authorities, and third parties (client, supplier, consultant, contractor, architect, et cetera.). The outcome of the organisational managerial strategy study forms the basis of a firm's structure (Zhu et al., 2022). Organisational strategy, like digital strategy, is the means by which specific subordinates receive directives from upper management. This contains the plans that outline how a certain organisation will use its primary resources to achieve particular objectives, whereas structure refers to how an organization's components work together to meet a common goal. There are several main qualities should a digital leader embody in their organization.

The factored cluster of internal and external aspects share commonalities with those by (Tagscherer & Carbon, 2023) who also leaders and organization literature item. In contrast to the factor found here, (Tagscherer & Carbon, 2023) used inductive analysis through systematic review found nine factors namely, vision and mission-centricity, vulnerability to change and VUCA, flat organisational structure, empowerment and decentralisation of decision-making, digital savvy and DT proficiency, collaboration and ecosystems, experimentation and risk-taking, teamwork and work environment, cultural awareness, and diversity. However, almost all of the factors identified in this study can be found in (Tagscherer & Carbon, 2023), possibly with the exception of the regulatory considerations component. Five elements were identified by Magesa & Jonathan, (2022) using factor analysis of the attributes of digital leaders: inspiration, visionary, absorbing uncertainty, innovation, and adaptation. Once more, there are many similarities between the clusters and those discovered in the current study. Nevertheless, Magesa & Jonathan, (2022) did not include any environmental clusters.

Although there are similarities among all the studies that factored the items, there are notable differences in the names and groupings of components within a cluster. For example, Tagscherer & Carbon, (2023) did not reported any significant different between internal and external aspects while the current study does. While Magesa & Jonathan, (2022) alluded to leaders style, this was strangely clustered with the inspiration cluster specifically. The present study clustered all internal and external factor with leader style together. These variations in naming and combining factors are evident in all research using varying item analysis methodologies. When the clusters are compared with studies that categorised the items a priori, these name variations become much more evident and prominent. To further refine the clusters of items promoted as either an external or internal digital leadership element, more a posteriori clustering research is required. This would encourage more insightful examination, comparison, and debate of the findings.

In terms of ranking among the internal aspects, digital strategy and expertise factor had the highest overall ranking. The most highly ranked variable in this cluster was need for leader participate competency program, followed by provide data analytics position and DT issue discussed in meeting regularly while virtual data information adoption, acknowledge the viewpoints of subordinates and contributes concepts via digital were rated high-medium. The results consistent with most finding on leader capability (Abbu et al., 2020; Magesa & Jonathan, 2022; Sinenko et al., 2021; Tagscherer & Carbon, 2023). The finding that digital strategy and expertise factor ranked the highest may be explained due to the fact that leadership competence and capacity are at the core of digitalization concerns and should thus be anticipated to assume a leading role. It is also anticipated that even within a cluster of digital mindset and skillset would rank the highest because IR 4.0 is now strongly linked to the forward-thinking leader which can be attributed to business innovation. It is also not surprising that replacing clerks with data analytics position ranked higher than keep up clerks position because the main aim of digitalization is not always associated with cost savings, even when certain costs might be. While data analytics demanded cluster in the digital strategy and expertise, regular discussion with subordinated would intuitively expect to DT improvement.

Leader commitment and trust factors were regarded as the second cluster of internal aspects of digitalization which devoted to taking the lead, followed by reliance visionaries and availability to trust third-parties digitally had a high important ranking. This finding are generally in tandem with other studies (Abbu et al., 2020; Magesa & Jonathan, 2022; Sinenko et al., 2021;

Tagscherer & Carbon, 2023). Moreover, long-term adaptation has to in line with the leader's trust toward towards DT through all ecosystem in their firm.

For the digital literacy and skill acquisition cluster, every item received a high-medium ranking. Awareness the existing DT was the most important item followed by digital mindset and skillset, emphasize the DT resources demand and lastly navigate implementation of DT. Again, these findings are consistent with other studies (Abbu et al., 2020; Magesa & Jonathan, 2022; Sinenko et al., 2021; Tagscherer & Carbon, 2023). It is not surprising that awareness is the highest ranked while digital mindset and skillset and DT demand and implementation is ranked last.

Collaboration and partnering factors ranked first external aspects to the DLP in firm organization. Specifically, the capital disperse for DT sources ranked as the key inhibitor for the adoption of DT in the construction sector. The next important variable were upgrade latest DT sources, structured digital asset management DAM and digital-based joint ventures. The remaining available of integration of information resources with consultant, investment to technology development and culture of sharing best digital practices. Once more, these results mostly agree with those of previous studies (Alshehhi et al., 2023; Morgan, 2019; Tagscherer & Carbon, 2023). With capital distribute source ranking as the greatest factor, firm managerial will seems to be a significant factor for expanded adoption of DT. Not surprisingly, the respondents prioritise economic needs over the digitalization agenda, as profit-making is the primary driver behind business existence.

Digital cybersecurity and policy factors were ranked as the second cluster of external aspects to digitalisation in Malaysia. Digital vision and mission followed by security cloud information trust had a high importance ranking while policies and regulation initiative ranked as medium in third position. Again, this is generally consistent with other studies (Alshehhi et al., 2023; Morgan, 2019; Tagscherer & Carbon, 2023). The results confirm that most developing nations' DT implementation is secure in terms of cloud IT trust. This supports the claim that the growing use of DT in the built environment is mostly due to the long- and short-term agendas towards trust IT resources. Policies and regulation initiatives rank lowest in the cluster, indicating that professional associations in Malaysia's construction industry are thought to be largely capable of providing digitization to construction firm.

Capital, workshop and training factors were ranked as the last cluster of external aspects to the DLP in the organization firm. Government financial incentive was the highest ranked item followed by subordinate digital training and workshop, availability of IR 4.0 construction services and fostering e-contract ecosystem with an important level rating of medium. Again, this is generally consistent with other studies (Alshehhi et al., 2023; Morgan, 2019; Tagscherer & Carbon, 2023). It is not surprising that workshop and training competency program to subordinates seems to have a significant role in the growing acceptance of DT, especially in light of the fact that government financial incentives were identified as the most essential driver. To look relevant in comparison to other developing nations, the government supports digital services like BIM, IBS, and e-contract services in the construction eco-system. Based on the ranking of Construction IR 4.0 as the least influential external factor under the capital, workshop, and training cluster, it seems that industry practitioners in Malaysia are generally well educated. This agrees with research by Maruthuvellu et al., (2021) showing that Malaysian construction professionals have a mediocre understanding of digitalization.

Conclusion

From Malaysian construction industry context shows the most important external aspects of DLP in organization are capital disperse for DT sources, digital competency workshop and training needs a higher priority than structured DAM and joint ventures efforts of government (CREAM, CIDB), non-government (client, consultant) parties. This organization capability are generally in line with findings in Malaysia by (Maruthuvellu et al., 2021; Muda et al., 2018) while the crucial internal aspects of DLP by leader in participate competency program, provide data analytics position, DT issue discussed in meeting regularly while virtual data information adoption, acknowledge the viewpoints of subordinates and contributes concepts via digital. These factors are quite different from those identified in Malaysia by (Hassan et al., 2008; Korn Ferry Institution, 2018) which are leader commitment and trust factors, devoted to taking the lead, reliance visionaries and trust third-parties digitally. To reconcile these significant disparities in internal digitization features in the Malaysian construction industry, more research is needed. Thus, the first step in any initiative to boost DLP by provide digital programme for leader and subordinate to build digital resilience. Legislation shall force founder or firm to digitise act and provision cost of digital competency and economic requirements to construction digital ecosystem environmental through Construction 4.0 initiative.

Although the results are generally consistent with a number of other related research, it is challenging to develop a more thorough correlation and discussion of individual and organisational items due to the large number of things reported in the literature and the majority of studies' focus on listing them. It is also impossible for a cluster to be comparable to one another on this topic since there isn't a widely acknowledged and approved cluster. Thus, additional research is needed to factor the item using a posteriori procedure in order to eventually reach consensus and adopt the standard cluster. This would result in a more thorough examination of the issue, more focused discussion, and more succinct suggestions for enhancing DLP, particularly in construction organisations. Nevertheless, there are some limitations on the outcomes. The most important ones are that the information may not be representative of the target community because it was obtained in an easy-to-access manner. Furthermore, it's possible that some leader and organisational capabilities were left out of the study since the items chosen to represent the internal and external components of DLP were not exhaustive. More investigation might concentrate on factor analysis of a comprehensive list of items to create more valid and trustworthy clusters of DLP's internal and external aspects. Then, it could be determined which of the clusters has the greatest influence on boosting the adaption of Construction IR 4.0 in developing countries that are lagging behind on the issue.

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