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An investigation into macro BIM maturity and its impacts: a comparison of Qatar and the United Kingdom

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ABSTRACT

Emerging frameworks of BIM implementation have proposed several attributes as measures of macro-scale BIM maturity within countries. Such macro-scale BIM maturity indicators determine the policy and institutional imperatives for BIM diffusion at the national and market levels. Although macro-scale initiatives are enacted to ultimately drive micro-scale (organisational) BIM adoption, it remains unclear whether they have been effective in practice. To ascertain this, the macro-scale BIM maturity of two countries (Qatar and the United Kingdom) are examined in order to identify the influence of the key macro-scale maturity factors on implementation at the micro-scale. Based on expert BIM maturity evaluation and interviews ($n = 16$), the maturity of both countries was ascertained and compared. Subsequently, a survey ($n = 73$) of construction businesses was used to solicit opinions about the relevance of macro-BIM maturity factors to implement at the micro-level. The study further identifies peculiarities with respect to the maturity levels of both countries. The findings indicate that both Qatar and UK have generally comparable levels of macro-BIM maturity, although, in some areas, both countries failed to meet the expectations of organisations in terms of facilitating their BIM adoption at the micro-level. Qatari organisations were of the opinion that further maturity is required in relation to *champions and drivers*, as well as *regulatory frameworks*. Similarly, in the UK, organisations were of the view that there was a need for more in terms of *champions and drivers* as well as *noteworthy publications* in order to facilitate micro-scale adoption.

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BIM; maturity; capability; Qatar; United Kingdom

Introduction

Building information modelling (BIM) is one of the promising advancements in the Architecture, Engineering and Construction (AEC) industry (Eastman, 2011). Currently, government agencies across the globe are making efforts in the implementation of BIM through various initiatives such as mandates, standards and guidelines (Succar & Kassem, 2015). These higher-level (nationwide) initiatives which are referred to as macro-level BIM maturity are considered as the antecedents of a successful BIM diffusion in the lower tiers such as organisational and individual levels (Succar,

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2010). Various studies in the past have measured the macro maturity of different countries, notably McAuley, Hore, and West (2018), Hamma-adama and Kouider (2019), Cheng and Lu (2015), Edirisinghe and London (2015), Fenby-Taylor et al. (2016) and Troiani et al. (2020).

Despite the wide acknowledgement of the importance of macro BIM maturity implementation factors, there exists a dearth of literature about their real impact on the micro-level (organisational) implementation. This gap exists in various countries, where macro-level BIM adoption is perceived to be higher. It ought to be noted that more than 60% of BIM-enabled projects in various countries are due to organisational level initiatives that promote and support BIM (Kassem & Succar, 2017). In this context, this study examines the macro-scale BIM maturity of two countries (Qatar and the United Kingdom (UK)) in order to identify the influence of the key macro-scale maturity factors on implementation at the micro-scale (Organisational). These two countries are selected due to similarities in the approach to BIM implementation and initiatives (Top-down), thus providing a good basis for benchmarking their effectiveness respectively as well as comparatively. The Qatari construction industry is the strongest in the Gulf region and has attracted significant attention in recent times as a result of the volume of construction activity as well as several initiatives to improve construction practices. National BIM implementation is still considered nascent in comparison with market leaders such as the UK, where there is a plethora of national initiatives have been enacted longer. Furthermore, Qatar being a host of FIFA World cup 2022 as well as the Qatari government's increased level of investments in the infrastructure with the aim of securing the country's 2030 vision, a pressing need has arisen in the Qatari construction sector to adopt BIM for smooth and timely project completion (Al Mohannadi, Arif, Aziz, & Richardson, 2013; Alattar & Furlan, 2017). With Qatar witnessing a huge construction boom, it is inevitable for the country to adopt a national approach to developing BIM standards (Future BIM Implementation, 2017). However, studies by Vukovic, Hafeez, Chahrour, Kassem, and Dawood (2015) among Qatar's construction stakeholders revealed that the industry is yet to be very clear about what BIM is despite having the right understanding of various aspects of BIM such as design and coordination, real-time collaboration, digital data management etc.

On the other hand, the BIS BIM strategy programme by the UK is currently the most ambitious and centrally driven in the world (Centre for Digital Built Britain, 2018). Centre for Digital Built Britain (2018) points out that the UK has the capability to capitalise its domestic programmes and to take the global leadership in various roles such as BIM exploitation, BIM services provision and BIM standard development. The UK's macro-scale BIM implementation journey started in 2011 when the government announced its construction strategy, requiring all its publicly funded projects to be BIM Level 2 matured by 2016 (Cabinet Office, 2011), followed by its BIM Level 3 initiatives as a part of Digital Built Britain programme (Centre for Digital Built Britain, 2018). Thus, the UK being an early adopter and global leader in BIM implementation, serves as a good benchmark to assess the influence of the key macro-scale maturity factors on implementation at the micro-scale in Qatar. The objectives of this study are: (1) To ascertain the macro-scale BIM maturity of the Qatari and UK construction sectors with the aid of existing maturity models; (2) Validate the UK's status as a mature country in BIM implementation as the basis for benchmarking Qatar's BIM macro maturity (3) Identify macro-scale BIM maturity factors influencing micro-scale implementation in both Qatar and the UK; (4) Ascertain the influence of macro-scale BIM maturity on microscale implementation in both countries and identify peculiarities.

Overview of macro-BIM maturity concepts and assessment

Succar and Kassem (2015) define BIM maturity as the gradual and continual demonstration of an ability to deliver BIM as an organisation, team, market or nation. Furthermore, Kassem and Succar (2017) explain the concept of macro-scale BIM adoption as the implementation and diffusion of BIM within a country or across a market, where 'macro' denotes a large collection of organisational adopters operating within a defined national framework and where implementation and diffusion of BIM at the country level is predicated on the concept of 'macro BIM maturity. This refers to institutional level and national scale processes and policies that denote the BIM readiness of a country. Thus, the macro-scale BIM adoption assessment aims to assist policymakers in deriving and/or assessing the macro BIM diffusion policies, strategies and plans within the country's market (BIMe Initiative, 2017). Succar and Kassem (2015) examined the factors and dynamics at national-scale, highlighting the prevalence of top-down, middle-out and bottom-up influencers which could be also described as the pull and push effect where the influencers are identified both in the government or regulatory bodies as well as in the industry organisations (mimetic pressure). In a top-down diffusion, this push is initiated by an authority to mandate the adoption of a specific solution that will improve the workflow (Succar & Kassem, 2015). UK's BIM level 2 mandate and Singapore's rolling BIM submission milestones are good examples of macro top-down BIM dynamics. When the adoption of the technology, process or policies at a lower level is without a coercive mandate, such BIM diffusions are referred to as bottom-up (Succar & Kassem, 2015). At the macro level, these dynamics initiates when the organisation at the lower tier adopts an innovative solution, which gradually became part of the practices, whereas at the micro-level these are initiated by employees at the lower tier. The middle-out (mimetic pressure) diffusion apply to those organisations and individuals who are in the median space (Succar & Kassem, 2015).

There are dozens of BIM-specific maturity assessment tools available (Giel & McCuen, 2014). Most of these available tools are capable of measuring the performance of the organisation and their team rather than across all the organisational or macro-scale (Hamma-adama & Kouider, 2019; Succar, 2010). Tools like BIM QuickScan (BIM Supporters, 2017), BIMe (BIMe Initiative, 2017), BIMScore (Strategic Building Innovation, 2017) etc are capable of assessing the organisational BIM capability/maturity (for a detailed review of these tools, refer Wu, Xu, Mao, & Li, 2017) whereas framework suitable for assessing macro-level maturity – e.g. market, industry or country scales are nearly absent in the AEC industry other than Succer and Kassem's maturity assessment model (Hamma-adama & Kouider, 2019; Kassem et al., 2013; Succar & Kassem, 2015). This model details the manifestation of macro-level maturity through policymaking by combining the three actives namely: *communication, engage, monitor* with three implementation approaches: *passive active and assertive* (Succar & Kassem, 2015). Succer and Kassem's maturity assessment model is one of the most cited (Yılmaz, Akçamete Güngör, & Demirörs, 2017) and widely-applied maturity model in several countries like Peru, Russia, Ireland, Egypt, Spain, Hongkong and Brazil (BIMe Initiative, 2017). This study is carried out mainly to assist the researchers and authorities to develop a strategy for an effective BIM implementation. Hence, Succer and Kassem's macro maturity model (Succar & Kassem, 2015) was adopted as the macro maturity assessment framework for this study. This assessment model consists of eight complementary components: *Objectives, Stages and Milestones; Champions and Drivers; Regulatory framework; Noteworthy Publications; Learning and Education; Measurements and Benchmarks; Standardised parts and Deliverables; Technology and Infrastructure.* This is supported by a detailed maturity assessment framework based on a five-point maturity assessment scale *(a) Ad-hoc or low maturity; (b) Defined or Medium-low maturity;(c) Managed or medium maturity; (d) Integrated or medium-high maturity, and (e) Optimised or high* (Succar & Kassem, 2015). The components are described in Table 1 below.

Related studies

McAuley et al. (2018) in their study measured the Marco BIM maturity of Ireland that aided in identifying key policies' outputs and the macro maturity components that were used to identify the key deliverables for the Irish BIM road map. The results of the study also helped in developing a 'managing-complex change matrix' which aided in identifying the necessary ingredients for a successful digital transformation programme for Ireland's AEC sector for the period 2018–2021. Hamma-adama and Kouider (2019) carried out a macro-BIM adoption study in the Nigerian context. The

Table 1. Components of BIM maturity at macro level (After Succar & Kassem, 2015).

	Macro maturity factor	Description
1	Objectives and milestones (OM)	Policy objectives defining progressive targets for BIM implementation at market/ country level
2	Champions and drivers (CD)	Key individuals or organisations promoting the value of BIM at market/country level
3	Regulatory framework (RF)	The normative, regulatory and legal systems supporting the delivery of BIM projects within a market/country
4	Noteworthy publications (NP)	Availability of relevant BIM documents addressing the implementation
5	Learning and education (LE)	Availability of BIM training and skills development opportunities within academia and market generally
6	Measurements and benchmarks (MB)	Metrics and scales to assess BIM capabilities at market/country level
7	Standardised parts and deliverables (SD)	Availability of standardised BIM components and use within the market
8	Technology and infrastructure (TI)	Hardware and software systems to support information exchange within the market

study findings acted as a guideline in developing a national BIM adoption policy. Furthermore, this study also assisted in classifying the macro maturity components and the key policies deliverables for developing a BIM roadmap for the Nigerian AEC sector. Cheng and Lu (2015) investigated the process in more detail by organising the effects as well as the area of interventions of the governmental institutions. This study further reviewed the government and public administration efforts in various countries to implement BIM and concluded that they play six key roles: *initiators and drivers; regulators; educators; funding agencies; demonstrators and researchers*. Further Edirisinghe and London (2015), in their study, compared the national and international BIM standardisation effort. They compared the policies of countries like the USA, the UK, Singapore Finland and Norway who are leaders in BIM adoption. Their study highlights that BIM adoption is influenced by the national government and instructional frameworks. A different approach was adopted by Troiani et al. (2020) who measured the macro maturity of Italy and further investigated its influence on the micro-level adoption among the Italian design firms. Their study revealed that BIM educational initiatives, as well as the availability of standard deliverables and components, were the most important macro-level initiatives for design firms in Italy. Cumulative evidence shows that there are several macro-level initiatives across countries that are considered to be global BIM leaders.

Methodology

This study is built on a sequential exploratory mixed-method research strategy based on a ‘Pragmatic’ philosophical stance (Dudovskiy, 2018). An extensive literature review was carried to acquire reliable secondary data and to ascertain the optimal national-level strategies to facilitate BIM adoption. Based on this review, Succar and Kassem’s (2015) maturity model consisting of eight maturity components was chosen for this study. Further, based on this conceptual model, factors relative to the eight pillars of macro maturity were identified from the literature (Table 2). This study consists of two phases (Figure 1), in the first phase the experts were asked to plot the macro BIM maturity of their respective countries (Qatar and UK) using the macro maturity assessment matrix which was emailed to them. Also, a qualitative interview following a structured format was carried out over the telephone to elicit further opinions from the experts. The second phase focused on a survey to ascertain how macro BIM maturity factors influence the organisational level (micro-level) BIM implementation in Qatar and the UK.

A quantitative strategy was adopted for the maturity assessments for both phases due to the adoption of known capability maturity modelling frameworks as well as its suitability for generalisation of the findings. On the other hand, qualitative thematic analysis of open-ended responses was employed to understand the rationale for ratings provided by experts in the appraisal of the macro BIM maturity in the first phase. The questionnaires used in the data collection were first screened and coded in Microsoft Excel 2016 before being exported to IBM SPSS

Table 2. BIM maturity factors.

Measure	Items	Reference
Objectives and Milestones	1. A well-defined national maturity level milestone for BIM adoption.	(Cheng & Lu, 2015; Edirisinghe and London, 2015; Fenby-Taylor et al., 2016; Kassem, 2014; Kassem & Succar, 2017; Succar & Kassem, 2015)
	2. A clear definition of BIM specific policy and objective for BIM implementation by government authorities or higher educational institution	(Cheng & Lu, 2015; Edirisinghe and London, 2015; Succar & Kassem, 2015)
Champions and Drivers	3. Support and incentives from construction policymakers for adopting BIM.	(Chan, 2014; Kekana, Aigbavboa, & Thwala, 2014; Matarneh & Hamed, 2017)
	4. Demand for BIM from clients or other firms	(Chan, 2014; Gerges et al., 2017; Kekana et al., 2014)
	5. Lack of supply chain buy-in (incompetent supply chain)	(Jung & Joo, 2011; Ruikar, Anumba, & Carrillo, 2005)
Regulatory Framework	6. The predominance of contractual issues such as (not limited to) licensing, insurance	(Ashcraft, 2008; Gerges et al., 2017; Kekana et al., 2014)
	7. Clear contractual requirements for BIM implementation	(Ahmed et al., 2014; Gerges et al., 2017)
	8. Clearly defined ownership, intellectual property rights & authenticity.	(Ashcraft, 2008; BIM Industry working group, 2011; Christensen, McNamara, & O'Shea, 2007; Furneaux & Kivvits, 2008; Gerges et al., 2017; Olatunji, 2011)
	9. Clearly defined liability and indemnity insurance.	(Ashcraft, 2008; Race, 2013)
	10. Lack of legal agreements	(Azhar, 2011; Ku & Taiebat, 2011; Olatunji, 2011)
Noteworthy Publication	11. Definition of Procurement guidelines such as contract forms, risk management etc	(Ashcraft, 2008; Vukovic et al., 2015)
	12. Clearly defined design and deliverable standards such as (not limited to) LOD, LOI, naming conventions, interoperable formats	(Ahmed et al., 2014; Ashcraft, 2008; Coates, Arayici, Koskela, & Usher, 2010; Gerges et al., 2017; Jung & Joo, 2011; Jung & Lee, 2015; Lee, Park, & Won, 2012; Ruthankoon, 2015)
	13. ROI of using BIM not clearly defined or lack of vision of benefits.	(Cheng & Lu, 2015; Fenby-Taylor et al., 2016; Kassem, 2014; Succar & Kassem, 2015)
Learning and education	14. Deficiency of trained individuals who can provide a holistic approach to BIM implementation.	(Chan, 2014; Gerges et al., 2017; Jung & Lee, 2015; Ku & Taiebat, 2011; Kazado, 2016; Kekana et al., 2014; Matarneh & Hamed, 2017; Vukovic et al., 2015)
	15. Cost of Implementation (Software & Training).	(Azhar, 2011; Crotty, 2012; Giel, Issa, & Olbina, 2009)
Measurements and Benchmarks	16. Certification of BIM maturity levels or standard compliance	(Kassem & Succar, 2017; Succar & Kassem, 2015)
	17. Professional board credits for BIM implementation achievements	(Kassem & Succar, 2017; Succar & Kassem, 2015)
Standard parts and deliverables	18. Certification of suppliers and manufacturers providing BIM components	(Fenby-Taylor et al., 2016; Succar & Kassem, 2015)
	19. Institution of official standardised components and libraries	(Cheng & Lu, 2015; Edirisinghe and London,2015; Kassem & Succar, 2017; Succar & Kassem, 2015)
Technology and Infrastructure	20. Lack of technological understanding and adoption.	(Aouad, Wu, & Lee, 2006; BIMCommunity, 2017)
	21. The complexity of systems such as design authoring tools.	(BIMCommunity, 2017)
	22. Interoperability issues	(BIMCommunity, 2017)
	23. Requirement for competent quality hardware and networking facility	(BIMCommunity, 2017)

statistic 24 for further analysis. SPSS 24 aided descriptive statistical analysis and inferential statistical analysis. Descriptive analysis aided in describing the basic feature of the data providing a simple summary of the sample and their measurements, whereas inferential statistics aided in identifying trends in the data obtained. An independent sample t-test was performed to compare the means of the two independent groups, Qatar and the United Kingdom in order to determine whether there is statistical evidence that the associated population means differ significantly. Also, correlation analysis was carried out to identify the linear relationship between variables.

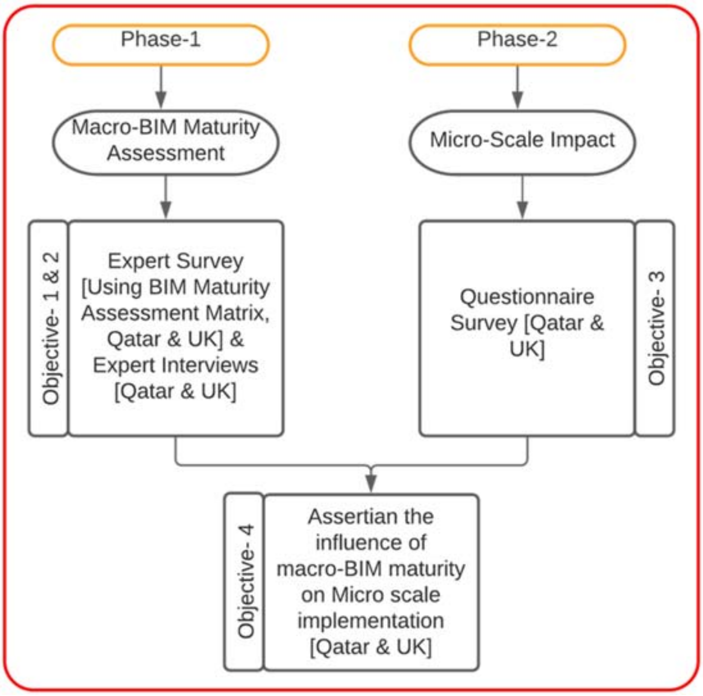

Figure 1. Research framework.

Design of survey

To collect the primary data, a close-ended self -completed questionnaire was developed and distributed among the BIM professionals in Qatari and the UK construction industry (phase-2). To clearly understand the participant's background, field of expertise and experience, the questionnaire was structured into two sections. A choice to express a neutral or uncertain opinion was also given whenever possible as closed-ended questions can distort the participants due to their nature (Saunders, Lewis, & Thornhill, 2015). Further, the option for a free text was provided to allow the respondents to input any comments they would like to express. The two sections of the questionnaire covered: (a) participant's background; (b) BIM implementation opportunity assessment. The first section analysed the participant's background covering major criteria such as but not limited to qualification, years of experience, BIM-enabled projects they handled and the size of the project. The second section of the questionnaire provided the list of factors (Table 2) that were identified through intense literature investigation. Marking scales were divided into five levels (a) Not at all important; (b) of little importance; (c) average importance; (d) very important (e) highly important. A pilot questionnaire was shared among experienced professionals to confirm the depth and appropriateness following which it was shared among BIM professionals in the UK and Qatar.

A probabilities sampling technique was used in the identification of the participants. Saunders et al. (2015) point out that probability sampling is best suited to quantitative surveys, as it is conceivable to answer research questions and to achieve objectives that are required to be statistically assessed of its attributes of the populace from the sample. The targeted sample size for the UK was 480, which is based on the sample size for surveys of construction professionals recommended by Mahamadu, Navendren, Manu, Joseph, and Dziekoński (2017). A sample size of 100 was decided for Qatar in accordance with consultancy with Qatari construction experts, revealing the existence of 50 active BIM organisations in Qatar; hence the quantity 100 encompasses an average of two BIM professionals from each organisation. Finally, a total of 580 samples was set for this study [n=480(UK) and n=100(Qatar)]. Upon distribution, 73 usable surveys were returned representing 12.6% of 580 samples; out of 12.6%, [52.05%(UK) and 47.95%(Qatar)] received, the response rate which is a typical scenario in construction management surveys (Mahamadu et al., 2017). Besides the snowball technique exercised, online surveys were circulated with invitations to online professional groups.

Macro maturity assessment and interview

The experts were asked to plot the macro BIM maturity (phase 1) of their respective countries (Qatar and UK) using the macro maturity assessment matrix which was emailed to them. Also, a qualitative interview was carried out over the telephone following a structured format to elicit further information and opinions. All the participants selected possess more than five (5) years of experience and they are the BIM drivers in their organisation/country they represent (Table 3). The assessment scale was divided into five maturity level corresponding to each of the eight BIM maturity elements from the macro maturity assessment conceptual model developed by Succar and Kassem (2015).

Participants selection for the macro-maturity assessment (phase 1) was based on the experience and role in driving BIM in the organisation/country that they represent. As it is subject-specific and the availability of experts is limited, the participants were selected through a purposive sampling or judgmental sampling method as well as snowball sampling methods. As the main focus was on selecting the participant's particular characteristic of the population who are able to plot the maturity of Qatar and the UK, the purposive sampling method was the best-suited sample selection technique for this study. Also, it is the most appropriate technique to emphasise the quality of the information rather than the representativeness of the sample (Saunders et al., 2015) which is of the least importance at this phase of the study. The identification of the sample population was carried out using the online platform *LinkedIn.com*. The identification was based on the position that they decorate, the qualification and years of experience that they possess and the complexity of the projects that they handled. Based on these criteria $n = 16$ (i.e. Qatar = 8, UK = 8) BIM champions were identified. Similar macro assessment studies were conducted by Kassem and Succar (2017) who also used an identical number of participants.

Table 3. Expert interviewee's background information (Qatar and UK).

	Respondent ID	Role	Experience (Years)	Organisation type	Organisation size (# Employees)
Qatar	QA-01	Design Director	12	Consultancy	4400
	QA-02	BIM Manager	8.5	Engineering Management	200
	QA-03	BIM Manger	11.5	Consultancy	2500
	QA-04	BIM Researcher	19.6	Educational Institution	3000
	QA-05	BIM Manager	11	Consultancy	13,800
	QA-06	BIM Manager	15.6	Consultancy	600
	QA-07	BIM Manager	14	Consultancy	8000
	QA-08	BIM Consultant	6	Consultancy	150
United Kingdom	UK-01	BIM Researcher	19.6	Educational Institution	3000
	UK-02	BIM Educator	14	Educational Institution	3000
	UK-03	Design Manager	6	Contractor	21000
	UK-04	BIM Manger	15	Contractor	20
	UK-05	BIM Engineer	5	Contractor	4100
	UK-06	BIM Manager	5	Contractor	6000
	UK-07	BIM Manager	7	Contractor	35
	UK-08	BIM Manager	6	Contractor	43

Findings

The findings of this study are presented in this section under two main headings: (1) Macro BIM maturity assessment; (2) Importance of macro-scale BIM adoption factors on BIM implementation in Qatar and the UK.

Macro BIM maturity assessment

Based on the macro maturity assessment carried out by the sixteen (16) experts (Qatar $n = 8$, UK $n = 8$) from Qatar and the UK the following maturity levels were plotted for each of the eight macro maturity components.

Objective stages and milestones

In Qatar, 25% of respondents plotted low maturity, medium-low maturity and medium-high maturity. Furthermore, 12.5% identified medium maturity and high maturity for this category. However, in the UK, 25% identified medium-low maturity and medium maturity followed by 12.5% who identified high maturity. The majority of participants (37.5%) identified the UK as medium-high mature with respect to *objective, stages and milestones*.

Champions and drivers

A majority (75%) of participants identified Qatar as medium-low in its maturity for this category, followed by 12.5% plotting low maturity and medium maturity each. Qatari respondents agreed that Qatar lacks a BIM driving force, barring certain self-driven initiatives, hence lagging in the enforcement of BIM in Qatar and plotting the country in medium-low maturity grade. On the other hand, the majority (75%) of the participants identified the UK as medium matured followed by 25% who plotted the UK as medium-high matured. The majority of the UK responses revealed that the industry fails to recognise the unquestionable benefits of BIM adoption despite the existence of BIM Drivers such as the UK BIM Alliance and various other task forces.

Regulatory framework

A majority (50%) of participants from Qatar graded this category as low maturity, followed by 25% as medium-low and 12.5% as medium and medium-high maturity. The Qatari construction sector faces major challenges imposed on BIM-enabled projects attributed to legal boundaries or lack of agreements as stated by respondents, an argument reinforced by reports detailing ownership and intellectual property rights as part of major challenges faced by these projects. In the UK, 50% identified the regulatory framework as medium matured, followed by 25% plotting medium-low and 12.5% as medium-high and high maturity each.

Noteworthy publication

In Qatar, 37.5% indicated low maturity whilst 25% of participants plotted medium-low and medium maturity followed by 12.5% plotting medium-high maturity. Participants mentioned that the absence of publications mirrors the bleak understanding of the benefits BIM can bring to Qatar. Few respondents acknowledged the existence of a deficiency of clearly defined design and deliverable standards and higher LOD demands by clients though it is inessential to completion of the project thus creating major information management challenge. Whereas in the UK, the majority (62.5%) marked medium-low maturity for this category, followed by 25% and 12.5% plotting medium-high and high maturity, respectively. Some of the respondents from the UK mentioned that existing publications are overly ambiguous and varied standards, contributing to the uncertainty in the AEC industry.

Learning and education

50% of the participants identified this category's maturity as medium-low followed by 25% for low and medium maturity each. Qatari BIM champions mentioned the shortage of BIM-based syllabus which restricts AEC from providing training facilities. This absence is further magnified by the insufficiency of competent manpower to provide a holistic approach to BIM. While in the UK, 50% identified the maturity for this category as medium followed by 25% identifying medium-low and medium-high each. Few of the UK respondents mentioned that even though institutes and universities in the UK are at the forefront in proving training, employers are unwilling to fund those courses, as their major concern is about the return on investment.

Measurements and benchmarks

In Qatar, 62.5% identified this category as low maturity, followed by 25% medium-low and 12.5% medium-high maturity. Qatar exhibited a lack of professional BIM certification and compliance board; hence respondents requested an RICS counterpart based in Qatar to act on BIM implementation achievements in the country. In the UK all the participants identified this category's maturity as medium-low. UK respondents stated that the UK's AEC industries fail to capitalise on the existence of active professional bodies such as the British Standards Institute (BSI), which provides certification as authorities failed to necessitate certification by these bodies. On the contrary, one of the respondents quoted, *I believe that sometimes certifications are not enough to make sure an organisation is really comprehending what BIM is and embracing it effectively*.

Standardised parts and deliverables

50% in Qatar identified low maturity for this category, followed by 37.5% and 12.5% plotting medium-low and high maturity, respectively. However, in the UK, 75% marked medium maturity and 25% identified medium-low maturity. The non-existence of neutral bodies such as the National Building Specification (NBS) library whose function is to provide object families, a task that consumes time and finance serves as a hindrance to the swift implementation of BIM, prompted most participants to respond with low maturity in the case of Qatar. On the other hand, the majority of UK identified medium maturity as the library rendered by NBS is inadequate to meet the market's demands as mentioned by a participant: *As we need to add more content to BIM models, we would find it useful to have a wider library. We as contractors can always develop ours but it takes time.*

Technology infrastructure

With respect to Qatar, 50% of the participants identified medium maturity, followed by 25% marking medium-low and 12.5% plotting medium-high and high each. In the UK, 75% of participants identified medium maturity, followed by 12.5% plotting medium-high and high maturity. Some of the users from Qatar and the UK highlighted the infrastructural requirements and the costs entailed are a major concern in the industry regarding embracing BIM.

Macro maturity assessment: data analysis

The data outlined in the previous section was examined using descriptive statistics (Table 4) to identify the central tendency-mean, mode and median. Further, the macro maturity component's mean values were ranked for Qatar and the UK which was plotted (Figure 2) to compare the macro maturity status of both countries.

Figure 2 below explains Table 4 and shows respondents' perception of the macro maturity of both Qatar and the UK. Also, from Figure 2, it is evident that the macro maturity level of the UK is far ahead of Qatar, except for the technology and infrastructure maturity component.

Table 4. Descriptive statistics macro maturity components (Qatar and UK).

	N		Range		Median		Mode		Means		Std. Deviation		Mean Rank		Maturity* Status	
Country	QA	UK	QA	UK	QA	UK	QA	UK	QA	UK	QA	UK	QA	UK	QA	UK
Objective, Stages and Milestones	8	8	4.00	3.00	2.50	3.50	1.00	4.00	2.75	3.38	1.49	1.06	2	1	ML	M
Champions and Drivers	8	8	2.00	1.00	2.00	3.00	2.00	3.00	2.00	3.25	0.53	0.46	4	3	ML	M
Regulatory framework	8	8	3.00	3.00	1.50	3.00	1.00	3.00	1.88	3.13	1.13	0.99	6	4	L	M
Noteworthy publication	8	8	3.00	3.00	2.00	2.00	1.00	2.00	2.13	2.88	1.13	1.25	3	6	ML	ML
Learning and Education	8	8	2.00	2.00	2.00	3.00	2.00	3.00	2.00	3.00	0.76	0.76	4	5	ML	M
Measurements and Benchmarks	8	8	3.00	0.00	1.00	2.00	1.00	2.00	1.63	2.00	1.06	0.00	8	8	L	ML
Standardised parts and Deliverables	8	8	4.00	1.00	1.00	3.00	1.00	3.00	1.88	2.63	1.36	0.52	6	7	L	ML
Technology Infrastructure	8	8	3.00	2.00	3.00	3.00	3.00	3.00	3.25	3.38	1.04	0.74	1	1	M	M

*Maturity rating scale: - Low(L)=1 - 2; Medium-low maturity (ML)=2-3; Medium maturity(M) =3-4; Medium-high maturity (MH)=4-5; High maturity (H)=5.

Table 5. Independent sample t-test- macro maturity Qatar and UK.

	N	Mean	Std. Deviation	Std.Error Mean	F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std.Error difference	95% Confidence interval of the difference	
												Lower	Upper
Qatar	8	2.188	0.539	0.190									
UK	8	2.953	0.463	0.164									
Equal variances assumed				0.192	0.668	−3.050	14.00	0.009	−0.765	0.251	−1.304	−0.227	
Equal variances not assumed						−3.050	13.688	0.009	−0.766	0.251	−1.305	−0.226	

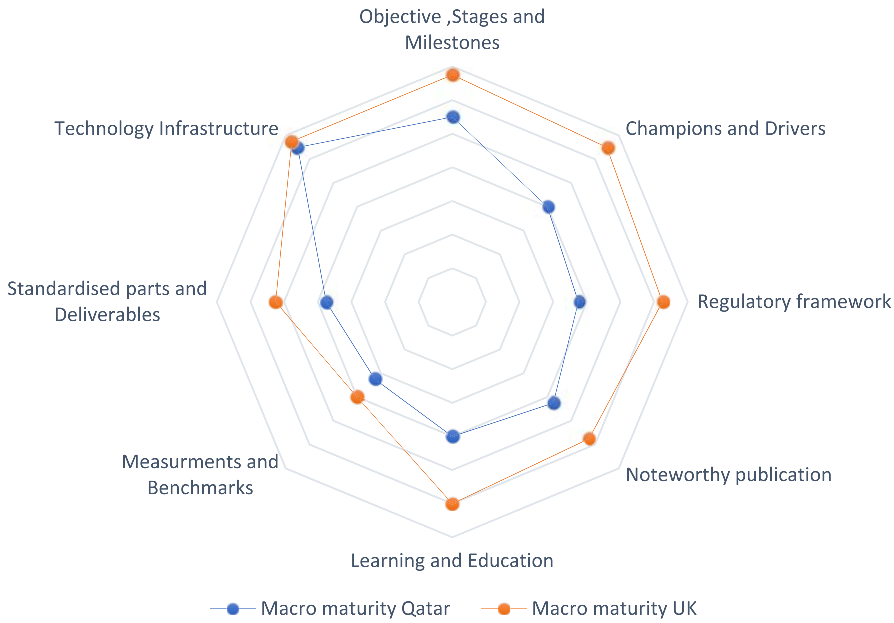

Figure 2. Macro maturity comparison – UK and Qatar.

Further, an independent sample t-test (Table 5) was conducted to identify the significance in the difference between macro maturity of both countries. This reiterated a significant difference in the scores for macro maturity of Qatar ($M = 2.187$, SD = 0.538) and that of the UK ($M = 2.953$, SD = 0.462) conditions; t (14) = −3.05, $p = 0.009$.

Importance of macro-scale BIM adoption factors on BIM implementation in Qatar and the UK

Demography and background information

In this section, participants' (Qatar $n = 35$ and UK $n = 38$) awareness and competence in BIM, as well as the background of the organisation they represent was solicited. In Qatar, out of the 35 respondents, the highest proportion (45%) were BIM coordinators followed by 20% BIM technician, 14.29% civil engineers, 5.71% of architects, BIM managers and design coordinators, 2.86% MEP engineers. In the UK, the majority (23.68%) were architects and BIM coordinator followed by 15.79% BIM managers, 13.16% BIM technician and project manager, 7.89% civil engineer and 2.63% MEP engineers. With respect to the experience of the respondents from Qatar, 34.29% had experience between 10 and 20 years, followed by 31.43% having experience between 2 and 5 years, 22.86% between 5 and 10 years, 8.57% having less than 2 years experience and 20.86% having more than 20 years of experience. In the UK, 34.29% had between 10–20 years' experience, followed by 31.43% between 2 and 5 years, 23.68% between 5 and 10 years, 21.05% having less than 2years and 10.53% having more than 20 years of experience. In Qatar and the UK, the majority (48.57% and 55.26% respectively) of the project, the cost was over £30 million. Further, respondents were asked about the BIM maturity level for the projects that they completed in both countries. In Qatar, 60% of the participants identified level 3 maturity for the projects they completed followed by 28.57% for level 2 and 20% for level 1. However, in the UK, 78.95% were level 2 BIM projects followed by 28.95% level 1 and 10.53% level 3. Both countries' overall demography information projected a diverse range of respondents with sufficient knowledge about the present state of BIM within their organisation.

Table 6. Descriptive Statistics Qatar & UK macro-scale maturity factors on micro-scale implementation.

		Range		Median		Mode		Means		Std. Deviation		Mean Rank		Degree of Importance	
Measure	Item	QA	UK	QA	UK	QA	UK	QA	UK	QA	UK	QA	UK	Aggr.Mean* QA	UK
Objective, Stages and Milestones	A clear definition of BIM – specific policy objectives for BIM implementation by government authorities or higher educational institutions.	4.00	3.00	4.00	5.00	4.00	5.00	3.77	4.21	1.123	0.905	3	2	V.Im	V.Im
Champions and Drivers	Support and incentives from construction policymakers for adopting BIM.	4.00	3.00	4.00	4.00	4.00	4.00	4.00	4.13	0.824	0.704	1	1	V.Im	V.Im
	Demand for BIM from clients or other firms.	3.00	3.00	4.00	5.00	4.00	5.00	4.14	4.47	0.538	0.762				
	Lack of supply chain buy-in	3.00	3.00	4.00	4.00	4.00	4.00	3.60	3.89	0.600	0.953				
Regulatory framework	The predominance of contractual issues such as (not limited to) licensing, insurance	3.00	4.00	4.00	4.00	3.00	5.00	3.57	3.63	0.840	1.149	5	5	V.Im	V.Im
	Clear contractual requirements for BIM implementation	3.00	3.00	4.00	4.00	5.00	5.00	4.23	4.32	0.770	0.809				
	Clearly defined ownership, intellectual property rights & authenticity.	3.00	3.00	4.00	4.00	5.00	5.00	3.80	3.95	1.282	0.928				
	Clearly defined liability and indemnity insurance	3.00	3.00	4.00	4.00	4.00	4.00	3.49	3.71	0.904	0.984				
	Lack of legal agreements or existence of legal uncertainty	3.00	3.00	4.00	4.00	5.00	4.00	3.74	3.63	1.255	1.051				
Noteworthy publication	Definition of Procurement guidelines such as contract forms, risk management etc.	4.00	3.00	4.00	4.00	5.00	4.00	3.51	3.84	1.610	0.789	4	4	V.Im	V.Im
	ROI of using BIM not clearly defined or lack of vision of benefits	3.00	3.00	4.00	5.00	3.00	5.00	3.63	4.45	0.829	0.921				
	Clearly defined design and deliverable standards such as (not limited to) LOD, LOI, naming conventions, interoperable formats … etc.	3.00	3.00	5.00	3.00	5.00	3.00	4.46	3.50	0.726	0.893				
Learning and Education	Deficiency of trained individuals who can provide a holistic approach to BIM implementation.	4.00	4.00	4.00	4.00	4.00	4.00	3.97	3.84	1.087	0.945	6	6	V.Im	V.Im
	Cost of Implementation (Software & Training). 3.00	4.00	3.00	4.00	3.00	4.00	3.71	3.74	1.151	0.921					
Measurement and Benchmark	Certification of BIM maturity levels or standard compliance.	3.00	4.00	5.00	4.00	5.00	4.00	3.74	3.39	1.197	1.128	8	8	V.Im	Avg. Imp
	Professional board credits for BIM implementation achievements 3.00	3.00	3.00	3.00	3.00	3.00	3.37	3.34	0.946	0.938					
Standardised parts and Deliverables	Certification of suppliers and manufacturers providing BIM components 3.00	4.00	4.00	4.00	5.00	4.00	3.66	3.45	1.467	1.032	7	7	V.Im	V.Im	
	Institution of official standardised components and libraries	3.00	4.00	4.00	4.00	4.00	5.00	3.77	3.89	0.829	1.110				
Technology Infrastructure	Lack of technological understanding and adoption	3.00	3.00	4.00	4.00	4.00	4.00	3.89	4.11	0.869	0.727	2	3	V.Im	V.Im
	The complexity of systems such as design authoring tools.	3.00	3.00	4.00	4.00	4.00	4.00	3.94	3.89	0.761	0.798				
	Interoperability issues	3.00	3.00	4.00	4.00	4.00	4.00	3.89	4.08	0.575	0.818				
	Requirement for competent quality hardware and networking facility	3.00	4.00	4.00	4.00	5.00	4.00	4.14	3.79	1.008	1.044				

*Not **Im**portant (NI)=0-1.49, Little Importance (LI)=1.50-2.49, Average Importance (Avg.Imp)=2.50-3.49,Very Important (V.Im)=3.50-4.49, Highly Importance=4.50-5.

Table 7. Independent sample t-test- micro maturity factors Qatar and UK.

Country	N	Mean	Std. Deviation	Std.Error Mean	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std.Error Difference	95% Confidence Interval of the Difference	
												Lower	Upper
Qatar	35	30.384	4.365	0.737									
UK	38	30.858	4.169	0.676									
Equal variances assumed					.064	.800	−0.475	71	0.636	−0.474	0.999	−2.466	1.517
Equal variances not assumed							−0.474	69.835	0.637	−0.474	1.000	−2.471	1.521

Assessment of the importance of macro-scale maturity factors on micro-scale implementation

A correlation analysis (Spearman's) was carried out to explore the association between relevant organisational characteristics and the BIM maturity as well as variations in perceptions about the relevance of macro-scale BIM maturity factors. A significantly strong positive association between the size of the organisation and BIM maturity level for projects completed in the UK ($p = 0.001$, $r = 0.508$) was identified. Similarly, in the UK there is a positive relationship between the size of an organisations budget and their BIM maturity level ($r = 0.469$; $p \geq 0.003$), whereas for Qatar no such significance was identified. Further, a descriptive analysis, independent sample t-test and correlation analysis was performed in section two of the questionnaire. Based on the statistical mean (Table 6), BIM maturity factors for both countries were ranked and ranking between the two countries was compared for significance using an independent sample t-test (Table 7).

The figure below (Figure 3) explains Table 6 and shows the perception about the importance of the BIM adoption factors among the organisations in both countries.

Plotting the rank further revealed that maturity factors that are important for embracing BIM at the micro-level in Qatar and the UK exhibit peculiarities. An independent sample t-test revealed no significant difference in the scores of Qatar ($M = 30.384$, SD = 4.36) and of the UK ($M = 30.858$, SD = 4.16) conditions; t (71) = −0.475, $p = 0.636$.

Comparison of macro maturity and micro BIM adoption factors in the UK and Qatar

Figure 4 below explains the comparison of the ranks derived from descriptive statistics (Tables 4 and 6) from both stages of the research. It revealed that in Qatar two of the elements, *champions and drivers* and *regulatory framework* require further development in order to meet the specific needs of organisations

Similarly, in the UK, two maturity elements, *champions and drivers,* as well as *noteworthy publication,* require further development in order to meet the needs of organisations. It ought to be noted that all other maturity elements of both countries are on par with their micro BIM

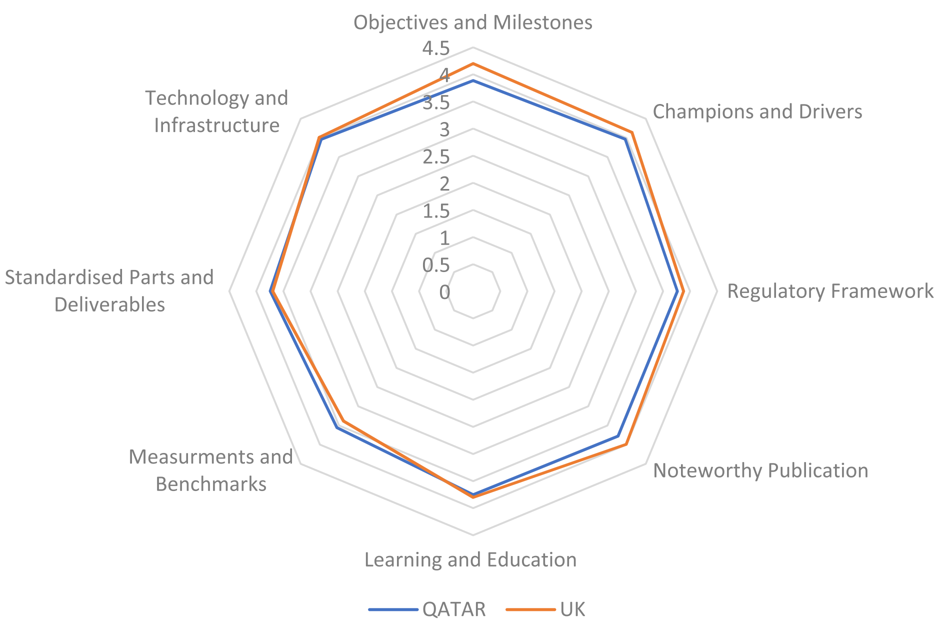

Figure 3. Comparison of Micro BIM adoption factors degree of importance in the UK and Qatar.

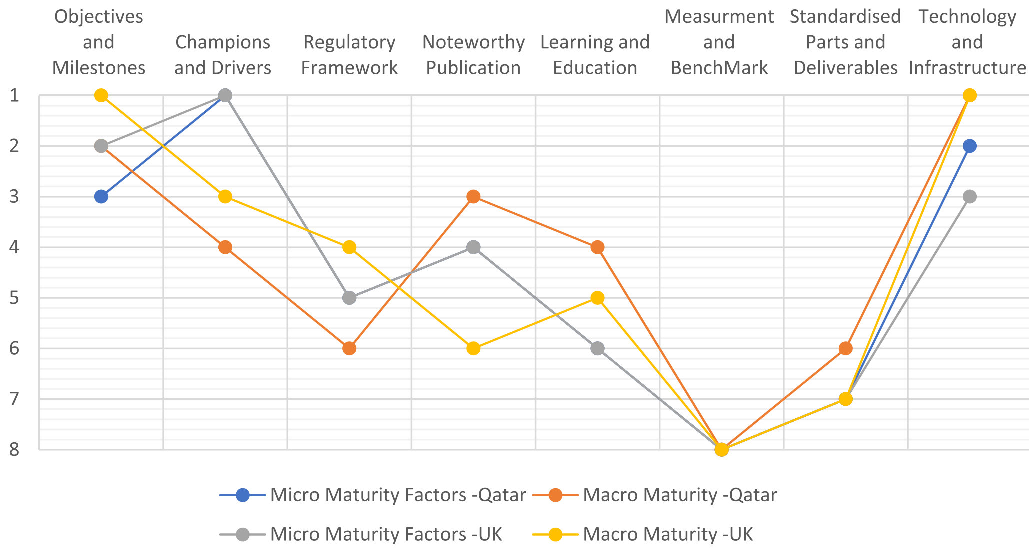

Figure 4. Macro maturity and micro BIM adoption factors – Qatar and UK.

implementation factors. Further, Spearman's rank-order correlation analysis was carried out to identify the monotonic relationship between the macro maturity of both countries and the micro-scale BIM adoption factors that will encourage the AEC industry in both countries to embrace BIM. A significantly strong positive association exists between the macro BIM maturity and micro BIM adoption factors in Qatar and the UK as $p = 0.029$ and $r = 0.759$ and $p=0.007$ and $r = 0.850$, respectively.

Discussion

Micro BIM adoption factors in Qatar and the UK

This study revealed that in Qatar the size of the organisation and budgetary size project has no significant relationship with the level of BIM maturity applied to the project. This finding greatly supports the comment of an expert interviewee from Qatar that

> Qatari AEC industry has seen exponential growth in the usage of BIM in preparation towards hosting FIFA 2022 world cup. Only a handful of organisations are available in the Qatari construction sector who are able to provide a holistic approach to BIM implementation. Due to this, regardless of the size or type of organisation, the entire supply chain needs to maintain the stringent standards stipulated by the authorities like the Supreme Committee for Delivery and Legacy of Qatar to win projects.

This means that a top-down approach is being relied on for enforcing the implementation of BIM. Whereas in the UK, a significantly strong positive relationship exists between the size of the organisation and the size of projects that they undertake with respect to the level of BIM maturity applied to those projects. Contrary to the case of Qatar, in the UK, the driving force for implementing level 3 BIM was set by government construction strategy with a deadline of 2025 (UK BIM Alliance, 2016). With the surplus number of construction companies in the UK, the AEC sector who can deliver BIM at different levels of maturity and in the absence of any such legacy projects, the transition of the weakest member in the supply chain is only driven by the aforementioned BIM mandates with a set deadline which is far ahead. Also, any such BIM level 3 initiatives in the UK are mostly driven by the middle-out initiatives which thus being fronted by capable and bigger organisation handling bigger and innovative projects (UK BIM Alliance, 2016). Section two of the survey for both the UK and Qatar revealed that both the countries professionals allocated the same degree of importance for the factors which will encourage BIM implementation at the organisational level. Analysis of this finding further proved that the degree of importance of BIM adoption factors for both countries has significantly no difference.

The state of macro BIM maturity in Qatar and the UK

Analysis of the macro maturity assessment in the first phase reiterates the UK's status as a leading BIM matured country. Kassem and Succar (2017) conducted a macro maturity assessment in 21 selected countries, including Qatar and the UK. Figure 5 compares the findings of Kassem and Succar (2017) and findings from this study for Qatar and the UK. It ought to be noted that this study identified that for Qatar most of the maturity component have increased the level of maturity (to next higher level) when compared to Kassem and Succar's (2017) findings, which was conducted a number of years before this study. This confirms that Qatar's macro BIM maturity is growing positively.

However, for Qatar, the maturity of *standardised parts and deliverables* appear to decline since Kassem and Succar's (2017) study. This is possibly due to the reason that building designs might have become more complex, thus increasing the requirement for more standardised parts and deliverables. To reiterate this one interviewee stated, *In Qatar, it is imperative to have a publicly accessible library like the National Building Specification (NBS) library, as the designs are getting complex and creating a parts library is a daunting task which consumes time and money*.

A similar comparison of the macro maturity results of the UK from this study revealed that most of the maturity components except *learning and education* for the UK has not increased significantly since Kassem and Succar's (2017) study. On the other hand, one of the maturity components, *noteworthy publication*'s maturity has changed from *medium* to *medium-low* maturity over time. One of the interviewees from the UK mentioned that *The UK has developed a handful of standards and documents which are confusing for many late adopters*. As more and more organisations started to adopt BIM into their workflow, the requirement for a *one-stop guide* that can easily guide the organisation down the path of BIM implementation is increasing (Troiani et al., 2020). This could have led to this

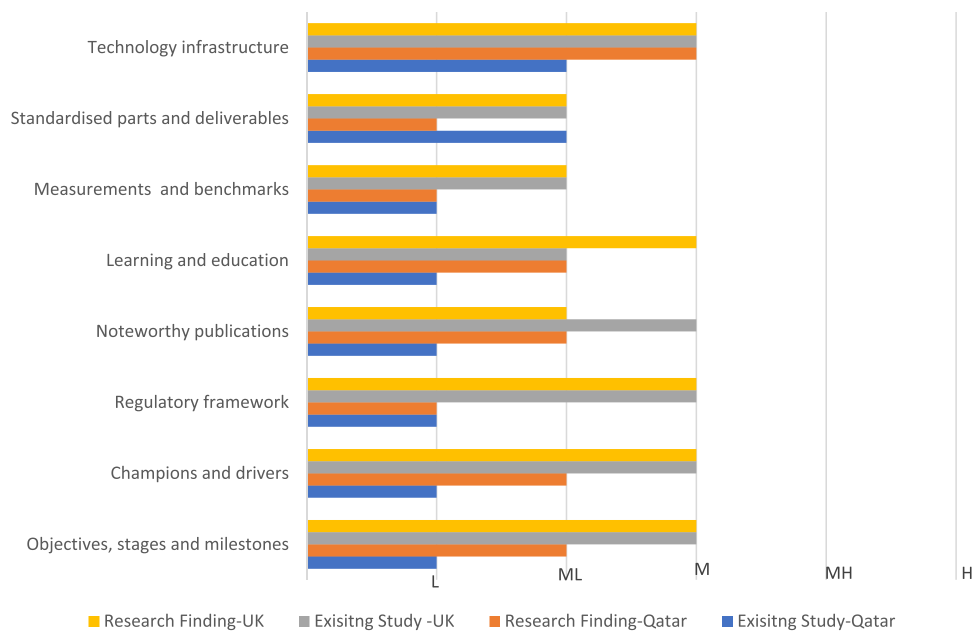

Figure 5. Comparison of macro maturity – existing study and research findings (Adapted from Kassem and Succar (2017)).

change in maturity for the *noteworthy publication* from medium to medium-low. With the recent publication of the ISO 19650 standard, this identified issue is expected to be addressed.

However, further plotting of macro maturity ranking with respect to the micro BIM adoptions factors revealed that the macro BIM maturity of Qatar and the UK are on a par with each other. This is indicative of the fact that the micro-scale BIM adoption factors, which influence organisations adoption of BIM in both countries, are very similar. This further implies that the macro maturity of both countries is ascending or increasing in a general sense. Statistical analysis reiterates this finding and reveals that a significantly strong positive relationship exists between the macro-BIM maturity of both countries and their corresponding micro BIM adoption factors.

Critical macro-level maturity factors that influence micro-level adoption

Two of the macro-maturity factors that were found to be of greatest importance to micro-level organisation for the adoption of BIM in Qatar are *champions and drivers*, and *regulatory frameworks.* However, these factors were found to not yet be at a desirable level of maturity. In Qatar, apart from a few independent non-profitable groups, there has not been a similar government-led drive on BIM implementation when compared to the UK over the last decade (Kazado, 2016). However, it ought to be noted that the current maturity of Qatar (identified through this study) in relation to *champions and drivers*, when compared to the findings of Kassem and Succar (2017), has improved although. From the participant's views, however, this is very important to mico-adoption, thereby requires further improvement in the Qatari macro BIM context. Furthermore, in the absence of BIM mandates like in the case of the UK or Singapore, BIM initiatives in Qatar are more or less middle-out in the structure (Kazado, 2016; Fahy, 2015). Also, in the absence of a clearly defined regulatory framework, micro-level organisations in Qatar are concerned about the legal and contractual issues that may arise when BIM is integrated into their workflows (Ahmed, Emam, & Farrell, 2014; Fahy, 2015). In Kassem and Succar's (2017) study, the regulatory framework was identified as one of the key areas where Qatar has invested its efforts. However, this study reveals that these efforts appear insufficient to meet the requirements of the micro-level organisations in terms of their BIM implementation efforts. Furthermore, rather than a top-down, assertive or mechanistic BIM implementation programme, Qatari organisations are more inclined towards a passive approach of BIM diffusion.

In the case of the UK, *champions and drivers; and noteworthy publications* are the two areas the micro-level organisations' thought influences their BIM implementation most albeit could improve in terms of the level of maturity at the macro level. According to Kassem and Succar (2017) the UK has already invested significantly in developing these two areas, although from the findings of this study there could be an improvement given its level of importance to organisations for their micro-level implementation. Even with the UK's BIM mandates, studies point out that half of the AEC sector in the UK believe that the BIM mandate is unsuccessful due to a lack of rigorous enforcement, thus many organisations are still at BIM level-1 (Chevin, 2017). While UK has been actively developed several *noteworthy publications* to aid the implementation of BIM level-2, studies (e.g. Kassem, Succar, & Dawood, 2015) suggest that the UK's strategy for achieving this was much less ambitious when compared to other countries like Singapore.

Conclusion

A macro-level BIM implementation plan is imperative for the facilitation of BIM adoption in any country. While BIM concepts and adoption continue to proliferate within organisations, the role of the market and country-level initiatives facilitating this is unclear. In line with this, this study adopted a mixed-method approach to explore the perceived relevance of macro-level BIM interventions to the micro-level BIM implementation efforts in Qatar and the UK. This study addressed this challenge by adopting 23 macro-level BIM implementation factors identified from the literature.

Two of the macro-maturity factors that micro-level organisation believe are most relevant to their BIM implementation was *champions and drivers* and *regulatory frameworks* albeit indicating macro maturity in this area is not adequately mature yet in the context of Qatar. In the UK the most important macro maturity factors for the organisation was *champions and drivers* and *noteworthy publications*. This study specifically recommends the need for a review of BIM implementation policies with an emphasis on the need for individuals, groups or organisations who can undertake the task of demonstrating the efficacy of the implementation (i.e. more case studies). This cannot be overemphasised, considering the positive impact of champions and drivers on innovation (Bossink, 2004). In Qatar, this could be achieved through the government's initiatives to set up groups or organisations that can demonstrate the benefits of BIM enables innovative solutions, process or promoting new standards and through drivers that can enforce these strategies. While in the UK, a handful of groups and organisations are at the forefront, encouraging and driving the AEC industries in adopting BIM-based solutions, more efforts are needed to reach the lower tiers of the supply chain. With the recent introduction of BSI BIM maturity certification, improvement(s) in this area is expected. Further, this study also recommends the need for a review of BIM implementation policies focusing on the area around legal and regulatory frameworks in Qatar as has been achived in countries like Singapore and to a large extent the UK. The relevance of this cannot be overemphasised, considering the pervasiveness of BIM and the associated risks posed by the information, technology and intellectual property rights. As this study investigated a currently evolving scenario, the validity of this study is strictly related to limitations in time. As identified from the available literature, Qatar and the UK's AEC industry's BIM implementation initiatives are accruing tremendous momentum and this research has addressed a precipitously changing scenario. Hence further research must be carried out periodically to ascertain the evolution of maturity in both countries. Further, this opens future research opportunities in this area by identifying the priority of each component based on the country and then applying the assessment model. In a fast-growing ambitious country like Qatar, abrupt changes in legislation and national markets will provide new opportunities for future research.

Disclosure statement

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