USING THE ARUP BIM MATURITY MEASURE TO DEMONSTRATE BIM IMPLEMENTATION IN PRACTICE

Abstract

Building Information Modelling Assessment Methods (BIM-AMs) are performance measurement systems that evaluate BIM across organisations, projects, individuals and teams. They focus priorities and help companies communicate their strategies both internally within their own businesses, and externally to other stakeholders. Currently, there are sixteen known assessments and each has its unique take on performance measurement. Amongst these models is the recently released BIM Maturity Measure (BIM-MM) which integrates critical elements of BIM including the BIM Champion, Common Data Environment and Employers Information Requirements. In this study BIM-MM is applied to 213 projects, in association with Arup, a global firm of consulting engineers. The aim of this substantial test is not only to investigate the implementation of BIM-MM in practice but more significantly to shed light on how BIM is being used in practice. In particular, the emphasis is on the relationship between the BIM Champion and the rest of the evaluated measures. Observations show that the overall scores of all projects is higher when the BIM Champion has a greater level of involvement in projects. BIM-AMs are of vital importance for policy-makers, professionals and researchers since they illustrate a broad snapshot of BIM adoption between and across organisations and countries. They are critical to the future directions of BIM agenda.

Keywords: BIM, Assessment Methods, BIM Maturity Measure, BIM champion

INTRODUCTION

In the last decade, the development of Building Information Modelling Assessment Methods (BIM-AMs) has been the subject of significant research (BRE, 2015; Giel, 2013; Kam, 2015; Succar et al., 2012). This development has led to sixteen Assessment Methods (AMs) introduced by both academics and practitioners. Each AM provides a unique perspective on BIM performance, with different sets of measures and different assessment focus. The first AM was the National BIM Standard Capability Maturity Model (NBIMS-CMM), developed in the U.S. by the National Institute of Building Sciences (NIBS, 2007). NBIMS-CMM consists of eleven critical BIM measures, including business process, delivery method, data richness and information accuracy. It focuses only on information management and has been therefore criticised for not reflecting the diverse facets of BIM. Critics have also questioned its usefulness and usability due to its structural limitations (Succar, 2010). So profound and powerful these critics were and resulted in the introduction of new models that tried to build on NBIM-CMM and provide more optimised models.

The emergence of new BIM-AMs was seeking better ways of measuring BIM. Frameworks such as the BIM Maturity Matrix (Succar, 2010), the Virtual Design and Construction (VDC) Scorecard (Kam, 2015) and the BIM Maturity Measure (BIM-MM) (Arup, 2014), have been designed to improve previous models. They have supplemented past measures with diverse areas of measurement that represent much broader dimensions of BIM e.g. policies, technologies and processes. Individually and collectively, coexisting AMs have contributed to the growing body of literature that examines BIM use. Despite this growth, the research field of BIM-AMs as a whole is still facing fundamental challenges. Until recently, there has been a lack of knowledge surrounding the ‘implementation’ of many assessments in practice. This is essential to shift the field of BIM-AMs from its theoretical basis into an effective and practical context, a challenge documented previously by Neely et al. (2000) who write extensively on performance measurement:

> “The process of designing a measurement system is intellectually challenging, fulfilling and immensely valuable to those managers who participate fully in it….[However,] the real challenges for managers come once they have developed their robust measurement system, for then they must implement the measures.”

This gap in literature is addressed here by implementing the Arup BIM-MM on a substantial dataset of 213 projects. The study considers the BIM-MM as an analytical framework and questions its ability to specify how BIM is being implemented across projects. Arup released the BIM-MM in December 2014 to assess and compare the maturity of BIM implementation within projects. It draws on the Organisational BIM Assessment Profile (CIC, 2013) under the Creative Commons 3.0 licence (Arup, 2014). This testing is important for professionals to review their progress over time, for academics to address the current challenges and opportunities of AMs and for policy-makers to create an overall picture of BIM implementation on a national scale.

LITERATURE REVIEW: BIM-AMS

Initial development of BIM evaluation systems is originally rooted in the software engineering Capability Maturity Model (CMM) which informed the first BIM-AM, the NBIMS-CMM (NIBS, 2007). Since then, multiple conflicting models have emerged shaped by both external and internal influences. Externally, AMs have been informed by the broader performance measurement systems in different fields, including business management, quality management and building environmental AMs. Internally, more recent BIM-AMs have built upon previous ones to avoid shortcomings. Together, these influences have impacted on the evolution of BIM-AMs in regards to the design process, type and range of measures and the ways results are communicated.

The significance and need for BIM-AMs has been highlighted by various scholars. A study by Succar et al. (2012) introduced three core advantages of BIM performance metrics. Such metrics enable teams and organisations to benchmark their own successes and (or) failures, evaluate their own BIM competencies and compare their progress against different companies in the Architecture Engineering and Construction (AEC) industry. Similarly, researchers in the ‘Computer Integrated Construction (CIC) research programme’ (2013), note that assessments help companies; internally to identify their current status, and externally to determine where they stand within the business market. Despite these advantages, there is still a shortage of literature which examines AMs in practice.

Most studies on BIM-AMs have focused on introducing and promoting new models, rather than implementing them in the architecture, engineering and construction industry. In the reviewed literature, publications of Case Study Projects (CSPs) is only available on seven AMs. For instance, the 'BIM Proficiency Matrix' (Indiana University Architect's Office, 2009) and the 'Organisational BIM Assessment Profile' (CIC, 2013) have contributed significantly to the field of BIM performance measurement, but no available publications document their implementation in practice. Table 1 presents all existing assessments according to their chronological order and reports the number of available CSPs.

Table 1 Availability of case study projects across the existing BIM-AMs

BIM-AM	**Year developed**	**Origin**	**No of CSPs**	**Reference**
NBIMS-CMM	2007	U.S.	11	(McCuen et al., 2012)
BIM Excellence	2009	Australia	-	(Change Agents AEC, 2013)
BIM Proficiency Matrix	2009	U.S.	-	(Indiana University Architect's Office, 2009)
BIM Maturity Matrix	2009	Australia	-	
BIM Quickscan	2009	The Netherlands	130	(Berlo et al., 2012)
VICO BIM Score	2011	Global company	-	
Characterisation Framework	2011	U.S.	40	(Gao, 2011)
CPIx BIM Assessment Form	2011	UK	-	
Organisational BIM Assessment Profile	2012	U.S.	-	
VDC Scorecard/bimSCORE	2012	U.S.	130	(Kam, 2015)
Owner's BIMCAT	2013	U.S.	2	(Giel, 2013)
BIM-MM	2014	**UK**	**213**	**(Arup, 2014)**
Goal-driven method for evaluation of BIM project	2014	South Korea	2	(Lee & Won, 2014)
The TOPC evaluation criteria	2014	Australia	-	
BIM Level 2 BRE certification	2015	UK	-	

As seen in Table 1 above there are sixteen models developed in different countries. The advantages and disadvantages of these models vary greatly. For instance, the BIM-MM is currently the only UK-based AM that evaluates the BIM maturity of 'projects'. It seeks greater linkages between substantial measures that reflect the broader perspectives of BIM, rather than focusing on one area, as in the NBIMS-CMM. It is a self-assessment and freely available for wider industry use, whilst in the BRE certifications a third-party is required to complete the assessment, which incurs a fee. Furthermore, BIM-MM is user-friendly and short to complete which attracts more interest compared to models that are detailed and complex. However, in order to optimise the BIM-MM, it should be implemented in practice which would maximise its effectiveness and suggest future directions of model to evolve.

RESEARCH METHODS

A comprehensive study is reported in this paper which documents the implementation of BIM-MM on 213 CSPs at Arup. The purpose of this AM is to enable comparison between projects, demystify BIM and to improve its capabilities across design and engineering disciplines (Arup, 2014). BIM-MM consists of eight parts: project, structural, mechanical, electrical, public health, facades, geotechnics and lighting. To complete the assessment participants have to specify one out of six possible maturity levels for each of the evaluated measures. These levels are 0 Non-Existent, 1 Initial, 2 Managed, 3 Defined, 4 Measured and 5 Optimising.

Once project assessment is completed (the first part of the BIM-MM) an overall 'Information Management Score' (IM Score) is provided. In addition, a "Primary Score", gives the average scores of the Project and the first four disciplines, usually Structures, Mechanical, Electrical and Public Health. The ideal scenario is to complete all seven parts of the BIM-MM to provide a holistic portrait of BIM implementation across project teams. However, projects can still be assessed based only on the project part and at least one of the eight other disciplines.

Data collection and analysis

Data collection was carried out by different project teams within Arup. The BIM-MM was advertised internally in Arup's offices for self-assessment use. This was supplemented with training videos, documentation and workshops to guide and encourage the use of the tool around the world. Then, individual teams identified appropriate BIM projects for examination. The project manager of each team ensured the completion of the assessment, either by carrying it out themselves, or by handing it to someone within the team. In both cases, different project members might be consulted to get more information needed for the test.

To analyse the results of the 213 projects, the comparative method was used. The comparative method is a fundamental tool of analysis, since it sharpens the power of description and focus similarities and differences across CSPs (Collier, 1993). Unlike 'case study' approach, comparative method does not provide highly contextualised and rich emphasis of individual CSP. Instead, it aims to identify "clusters of elements or configurations that support particular outcomes" (Schweber & Haroglu, 2014). It also assists in identifying the distinctive connections, trends and patterns when comparing processes and relationships across cases (Ragin, 1989).

FINDINGS: APPLICATION OF BIM-MM

Analysis of the 213, exhibited in Figure 1, provides an overarching view of how BIM is being implemented across some critical measures. The figure shows the distribution of these projects through the six levels of maturity. In particular, it focuses on the first part of the BIM-MM, namely, the 'Project BIM Maturity' section, which consists of eleven measures. As seen in Figure 1, the numbers of projects with low levels of maturity (level 0 Non-Existent, level 1 Initial and level 2 Managed) is higher than the number of projects with high levels of maturity (level 4 Managed and level 5 Optimising). Examples can be found in six measures i.e. BIM Design Data Review, Project Procurement Route, Marketing Strategy, Open Standard Deliverables, BIM Contract and BIM Champion, in which all have fewer projects with higher levels of maturity. For instance, in Project Procurement Route, the number of projects allocated to level 5 Optimising is over five times fewer than projects with level 0 Non-Existent (7% and 39% respectively).

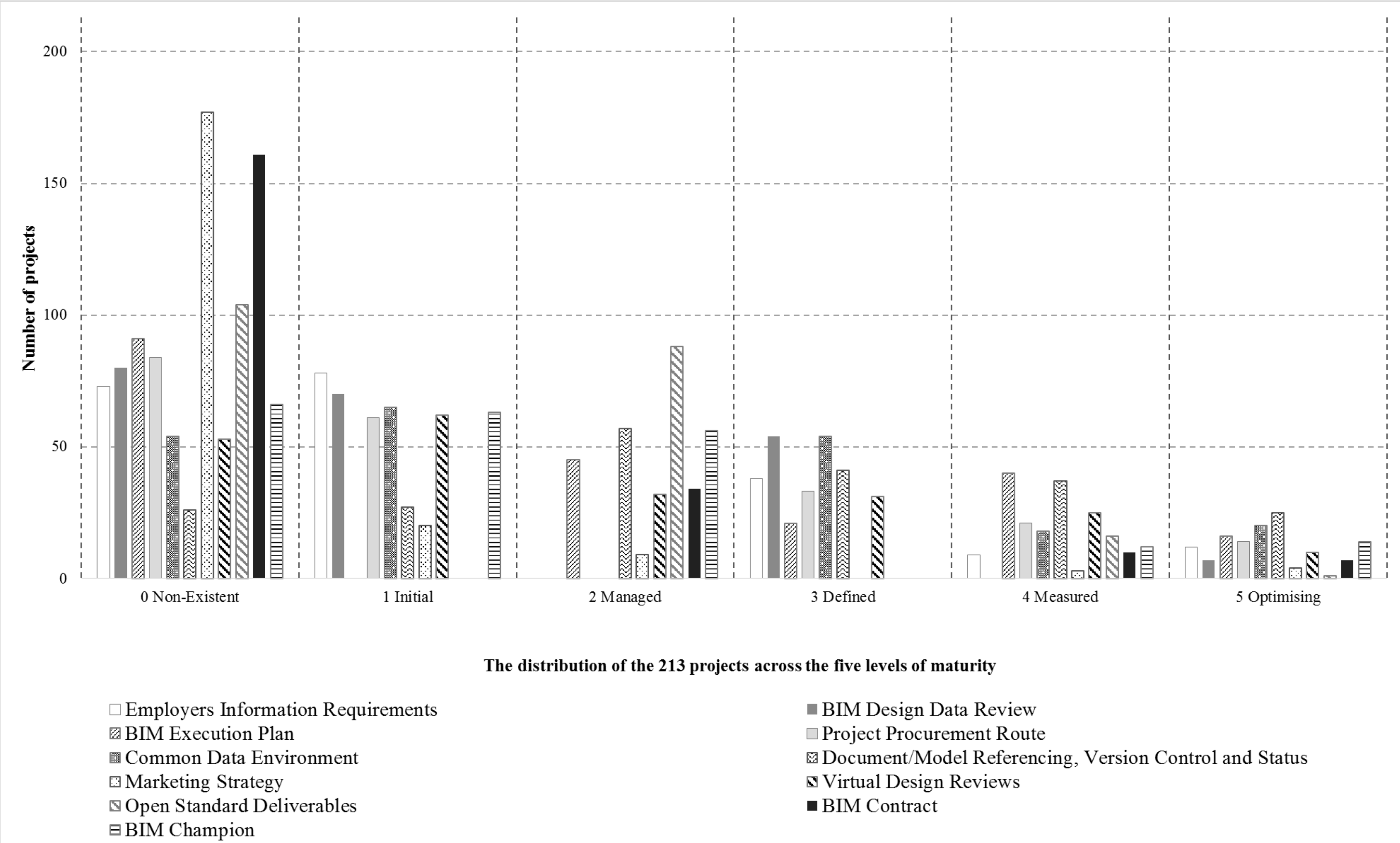

Figure 1: The performance of 213 case study projects against the five levels of maturity across the eleven measures

The mapping of these projects enables specific areas of strengths and weaknesses to be identified. Three quarters of all the 213 projects (76%) have no BIM contract or provide poorly-defined BIM agreements in consultant appointment (top left of Figure 2). As a result, the company could explore the impact of this factor on their business. If the absence of a contract reduces the potential benefits of BIM, then all parties, including contractors, should sign up to an industry standard BIM contract. Similarly, high numbers of projects have no Marketing Strategy (83%), defined by the BIM-MM as 'BIM specific case studies to showcase and share the key points'. Whilst the lack of marketing strategy will not necessarily have a negative influence on the adoption of BIM, nevertheless the act of engaging with this AM has identified a potential area for development which might otherwise have been missed. Strengths can also be identified. In the 'BIM Execution Plan' (BEP) measure, 57% of the projects range between level '2 Managed' to level '5 Optimising', which means that BEPs have been used in all these projects to formalise goals and specify information exchange. Another example of strength is found in Document and Model Referencing, Version Control and Status with 75% of projects ranging between level '2 Managed' to level '5 Optimising' (bottom left of Figure 2).

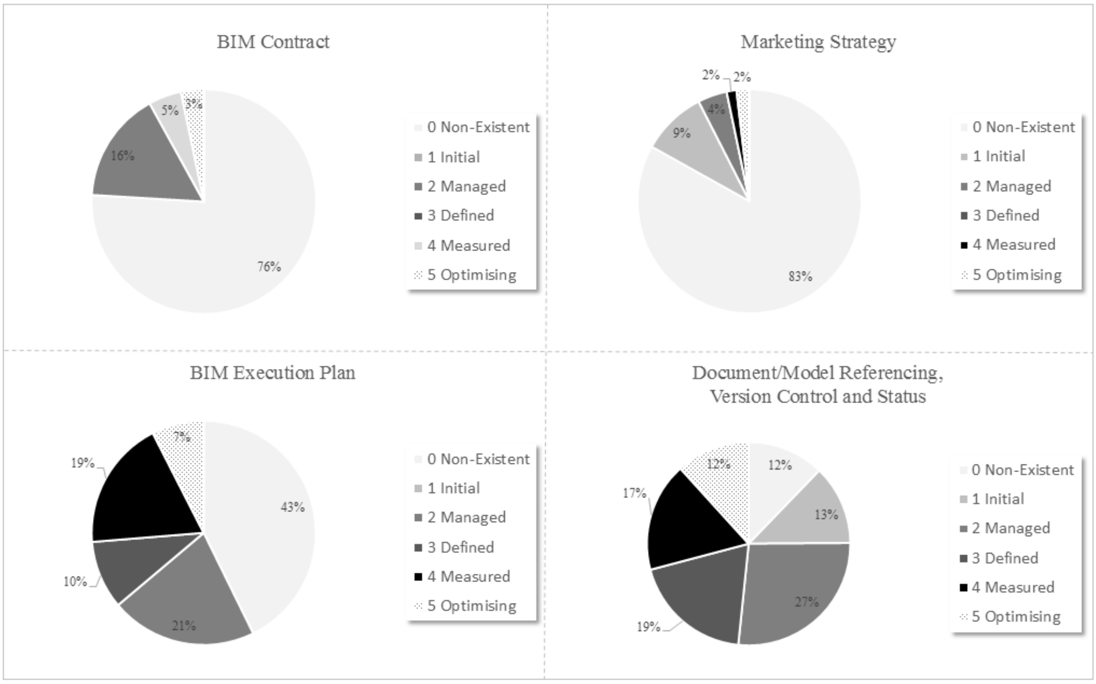

Figure 2 Examples of the distribution of the 213 projects across the six levels of maturity in four different measures

The relationship between the BIM Champion and the rest of the measures

With the development of BIM, new roles have emerged in the AEC industry. 'BIM Champion' is one of these emerging roles which is evaluated in the BIM-MM. The BIM Champion is the person who has the motivation and technical skills to guide teams to improve their processes, push BIM utilisation and manage resistance to change (CIC, 2013). The degree of a champion's engagement varies across different companies and sometimes within the same company across different projects. According to BIM-MM, five levels of maturity of 'BIM Champion' are identified (most of other measures have six maturity levels). Analysis of the 213 projects shows that approximately 70% of these projects have a BIM Champion, but with different levels of engagement, this is presented in Table 2.

Table 2 The five maturity levels of 'BIM Champion' and the numbers of projects allocated to each level

Maturity level	Description	No of projects	%
0 Non-Existent	No BIM Champion on this project	66	31 %
1 Initial	BIM Champion is identified but limited time commitment to BIM initiative	63	30 %
2 Managed	BIM Champion with adequate time commitment on this project	56	26 %
4 Measured	Leadership Level BIM Champion with limited time commitment on this project	12	6 %
5 Optimising	Leadership level BIM Champion working closely with BIM Taskforce champion	14	7 %

The overall scores of projects allocated to each level of maturity have been averaged to isolate the effect of having a BIM Champion. For example, there are 66 projects allocated to level 0 Non-Existent BIM Champion. The average 'Project IM Score' of these 66 projects is 14.6% and the average 'Primary Score' is 23.5%. The same approach is applied to projects with all five levels of maturity and the results are shown in Figure 3. Interestingly, the average scores of projects are higher when the BIM Champion has a greater level of involvement in the BIM implementation process. The average of IM Score of projects with Champion level 5 (57.6%) is over three times the average scores with no BIM Champion (14.6%).

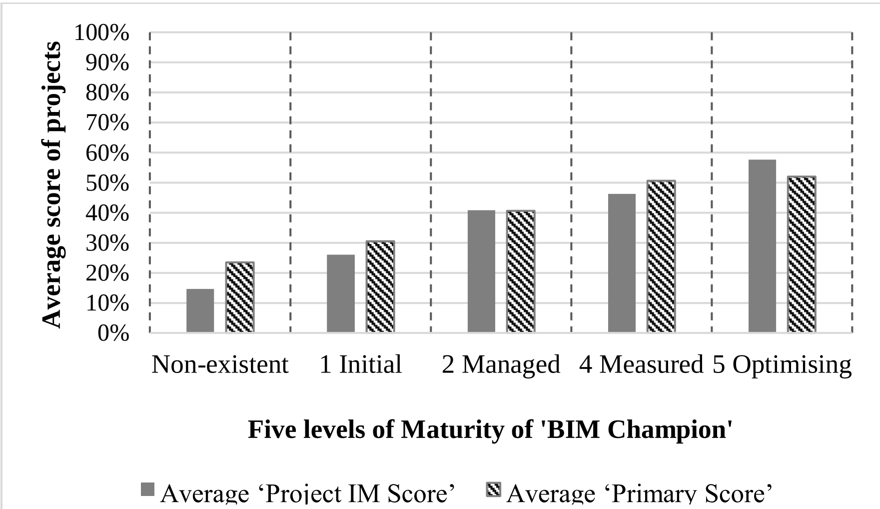

Figure 3 The link between the existence of BIM Champion and the project scores

Another interesting finding is the relationship between BIM Champion and the rest of the individual measures. Figure 4 shows the average scores of each of the ten measures across the 213 projects, split in terms of the BIM Champion level. Overall, there is a significant growth in the average scores of all measures between level 0 and level 4 of BIM Champion. All average scores of level 4 are at least twice the average score of level 0, and in some instances scores are significantly higher. This is exemplified in the BIM Execution Plan (BEP) measure, where average score in level 4 is 10 times the average score of level 0 (3.45 and 0.3 points respectively). The observed relationship between the BIM Champion and the overall scores of projects might be explained in the following manner. BIM Champions undertake actions at the leading edge of BIM's three core dimensions: technology, process and policy (Change Agents AEC, 2013). By looking at these three dimensions, BIM Champions ensure that teams are not treating BIM according to its fractional elements, but rather they are looking at the wider picture. They also define the current status of BIM and guide teams towards desired goals and aims. However, what is unexpected is that half of the measures have lower scores in level 5 compared to level 4. This is exemplified in BEP, Virtual Design Reviews (VDR), BIM Design Data Review, BIM Contract and Marketing Strategy. For instance, there are 1.3 points differences between level 4 and 5 of the VDR. The reason for this is not clear. In the literature there are no detailed studies that focus on the role of BIM Champion and this will require more specific research to identify the underlying cause.

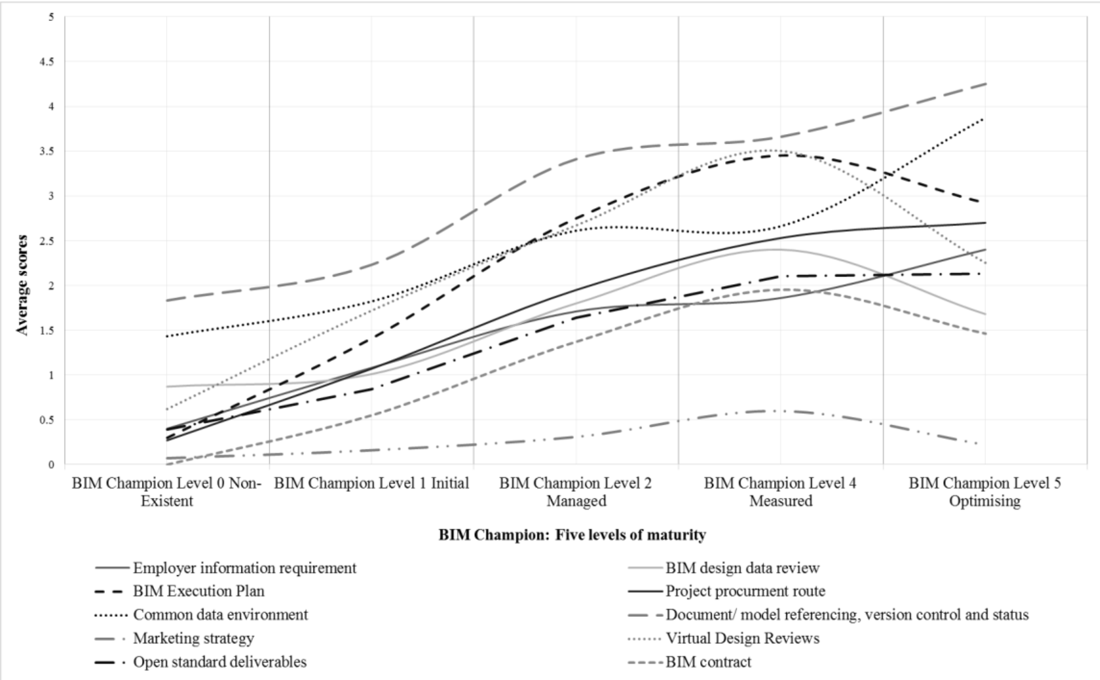

Figure 4: The impact of the BIM Champion on the rest of the measures

DISCUSSION

This comprehensive study generates new insights over previous studies that evaluate BIM in use; in particular, by treating the BIM-MM as a method to observe how BIM is being implemented in the AEC industry. Through the use of BIM-MM, Arup is "aiming to drive a more open conversation about the use of BIM to improve its positive impact across the project spectrum" (Arup, 2014). By doing so, the BIM-MM can be used to engage different project teams in greater dialogue, which informs the decision-making process. This particular role of AMs has not been documented previously in the BIM literature, but it has been acknowledged in different research fields (Cole, 2006).

The maturity levels of the measures vary significantly across the 213 projects and it is important to note that not every project is expected to obtain level 4 Measured or level 5 Optimising. This is similar to the findings of Kam (2015) who argue that it is not necessary to push every project team to achieve the highest levels of maturity in every measure. Instead, the target should be defined by the organisation which should reflect the desired expectations. In their study which applies the VDC Scorecard to 108 projects, (Kam et al., 2013), none of the examined projects have been allocated to 'Innovative Practice' overall (the VDC's Scorecard levels of maturity are Conventional Practice, Typical Practice, Advanced Practice, Best Practice and Innovative Practice).

One interesting finding is the relationship between the BIM Champion engagement in the BIM implementation process and the overall scores of projects. It has been observed that the average score of BIM maturity levels is significantly higher when a BIM Champion has a greater participation in the project. However, part of the project score is directly due to the increase in BIM Champion maturity, but this in no way accounts for all the increase in score. Companies should, therefore strengthen the role of BIM Champions in their practices in order to achieve sharper and more efficient business process of BIM. So no matter what level of maturity the 'BIM Champion' is, their existence, even if with limited time, leads to at least a 10% increase in average scores of projects. However, the case for investing resources in implementing a level '5 Optimising' BIM Champion is perhaps less clear.

CONCLUSIONS

Since 2007, there has been remarkable developments in the field of BIM-AMs, with at least sixteen assessments to date. Despite this growth, there are still fundamental challenges to be addressed. In particular, the shortage of case study projects, which is one of the main challenges in performance measurement. Previous research in the field of BIM-AMs tend to focus on introducing new models without, in many cases, implementing them in practice. This lack of implementation makes it difficult for both academia and industry to understand the practicality of these AMs, their advantages and shortcomings. Arup is pushing the boundaries of BIM and they are currently leading the way in regards to BIM evaluation systems in the UK's AEC industry and beyond. Future directions of the BIM-MM will focus on supplementing the model with financial measures. The BIM Maturity Measure is about to become a key performance standard for Arup's global offices. The authors believe that such implementation is necessary if the opportunities promised by the effective BIM implementation are to be capitalised upon.

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