BIM-adoption within Small and Medium Enterprises (SMEs): An existing BIM-gap in the building sector

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Abstract

The AECO[1] industry is fast going digital, with Building Information Modelling (BIM) becoming an essential part of it. BIM adoption is seeing an expanding trend as more and more building sector stakeholders can realize how by prototyping the building virtually to be built, they can review the design more efficiently, obtain more accuracy in construction and if need be, evaluate alternatives concerning cost and other parameters. In this regard, Small and Medium Enterprises (SMEs) form a significant part of the sector; thereby their innovative practices are crucial in performing BIM within an Integrated Design (ID) schema. Many governments support adoption of BIM-oriented ID approaches on their national markets, yet the involvement of small companies in the common BIM-adoption is considered inadequate. As such, a common BIM-gap exists and negatively impacts the overall pace of adopting innovative technologies in construction. Inspiring SMEs to adopt BIM can help the AECO industry including each individual firm enhancing their productivity as well as economic profit and reducing risks. The sooner small and medium companies decide to undertake BIM transformation and dumping the traditional construction process as the only right choice the better for all stakeholders. On the basis of this underlying hypothesis, the aim of the present research study is firstly to identify issues that are the cause for the BIM-gap to emerge and secondly to investigate what actions could be undertaken with an attempt to reduce it.

The research methodology used in this study consists the data collection from various experienced practitioners including Site Engineers, Construction Managers, Schedulers, Cost Estimators, BIM coordinators, Consultants, and Designers with an understanding of the on-site BIM implementation. In order to collect the appropriate amount of data in a timely manner that could serve further deduction, a mixed method called triangulation is used, including phone interviews; an extensive literature review; non-interactive interviews in the form of online forum discussions including an online survey and review of relevant practitioners' opinions. Data collection is then followed by an analysis of the collected data and the extraction of most relevant facts. This is the conclusion of this study that the costly BIM-adoption appears unappealing to many SMEs due to various obstacles containing lack of motivation and need to change, as well as the issue of many of the popular BIM platforms not being designed to suit the specific needs of SMEs.

Keywords: Building Information Modelling (BIM), BIM-adoption, Small and Medium Enterprises (SMEs), Integrated Design (ID).

[1] Architecture, Engineering, Construction, Operation

1. Introduction

The AECO industry is fast going digital, with Building Information Modelling (BIM) becoming an essential part of it. Krygiel et al. (2008) discuss BIM is an emerging methodology in the AECO industry since the intelligent digital three-dimensional model-based process of BIM can be used to plan, design, structure, manage, and analysis buildings. Succar (2009) states BIM is a set of technologies, processes, and policies enabling multiple stakeholders to design, construct and operate a facility collaboratively. This underlines three critical factors to BIM including people, process, and technologies. BIM (Eastman et al., 2011) has the potential to aid designers to provide the required geometrical and analytical data of an existing building 3D model to select and evaluate the proper type of design alternatives during the early design stage (Kamari et al., 2018a; Kamari et al. 2018b) and to make decisions that have a significant impact on the life cycle of the building projects.

BIM technology allows Integrated Design - ID to flourish, encourages - and provides a vessel and conduit for - the sharing of information between the design and construction team (Deursch, 2011). As such, BIM enables Integrated Design – ID and therefore makes it possible. ID through BIM can be understood as a collaborative method for designing buildings that emphasizes the development of a holistic design (Kamari et al., 2018c). It strives to be holistic in that it involves stakeholders (architects, engineers, contractors, and clients) from the earliest stages, each having input into what goes into making the decisions that will lead to the completed project. It, therefore, strives to take every team member's point of view into consideration, and it is holistic in that these decisions are made with all the information shared at one time, up front and not in the more traditional linear fashion, each entity maintaining and controlling the distribution of its own locus of information (adopted from Deursch, 2011). ID and BIM are seeing as expanding trends as more and more building sector stakeholders can realize how by prototyping the building virtually to be built, they can review the design more efficiently, obtain more accuracy in construction and evaluate alternatives concerning cost and other parameters.

1.1 BIM-adoption around the world

Figure 1 illustrates the result of a study that was carried out by RIBA Enterprises (NBS, 2016) concerning the awareness and adoption of BIM within the international design community. It demonstrates that the awareness of BIM throughout the sector is nearly above 90% for the four out of five surveyed countries.

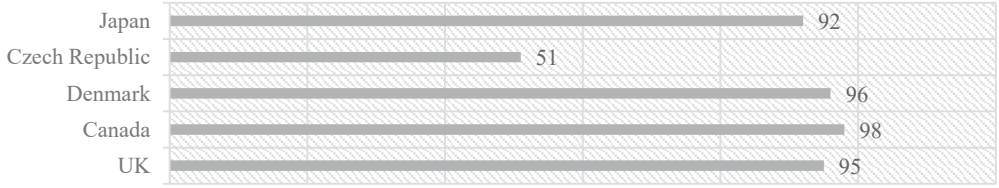

Figure 1: BIM-adoption (adapted from NBS, 2016)

In this survey, BIM awareness and adoption are highest in Canada and Denmark, and lowest in the Czech Republic. Both Canada and Denmark are reported a majority using BIM on at least some projects in the previous year. In Japan and the UK, the figure is just under half. It is noticed that BIM is increasingly becoming the norm for construction information across a range of countries and adopting BIM may become a prerequisite for working overseas. Even though the level of adoption of the technology is raising every year, as the outcome of the second survey by RIBA Enterprises (NBS, 2018), it is observed that there is still more than one-fourth of UK companies that do not utilize BIM technologies.

It is worth considering why such a large number of companies does not decide to make this transformation together with how BIM-adoption of the market can be improved (Hosseini, 2016; Forsythe, 2014). Distinguishing the BIM non-users with regards to practice size (small practice - 15 staff members or less, medium – 16 to 50 and large – more than 50) exposes a tendency, which small

companies are more resistant in the implementation of BIM processes in their practice (as demonstrated in Figure 2) than their more substantial equivalents. Ghaffarianhoseini et al. (2016) based on their research on investigating the BIM readiness and implementation strategy for SMEs (Small or Medium Enterprises) in the UK, argue that almost 75% of UK's SMEs had yet to start their BIM journey in 2016.

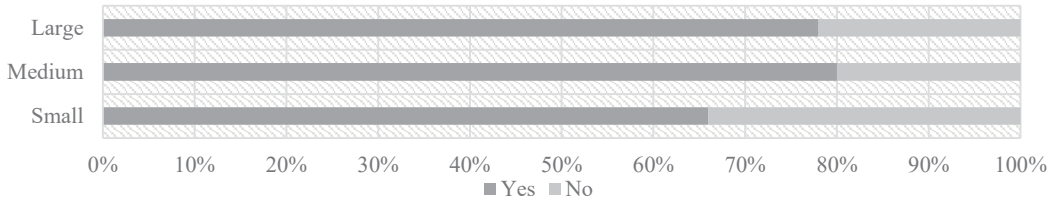

Figure 2: BIM adopted regarding the scale of the project (adapted from NBS, 2018)

1.2 Revealing a BIM-gap in terms of adoption

The BIM-gap refers to a growing digital division between BIM-adopters and non-adopters in the construction sector. BIM-related technologies are very rarely integrated across all phases of a project and its involved stakeholders, and thus the potential is not fully obtained (Dainty et al., 2017, Hosseini, 2016). Since the adoption of BIM occurs with facing specific challenges (i.e. financial aspects), larger companies are often better equipped to overcome them. As a result, those with the most resources begin adopting, training and learning skills and ultimately take advantage of the opportunities that i.e. BIM can bring into a company. These companies adopt earlier and gain more from adopting BIM technology, which leads to increasing inequalities in the market (Dainty et al., 2017; Forsythe, 2014). Poirier (2015b) states that there is also an insufficient or disproportionately low representation on BIM implementation for the SMEs in the relevant research findings, which tend to generalize and decontextualize real practices in the AECO industry. Since BIM-adoption requires collaboration and handing the model from the design team through the entire supply chain, according to Forsythe's (2014) analysis of BIM-adoption in Australia, small contracting enterprises are the most reluctant towards BIM technologies and constitute the weakest link in BIM-based supply chains. The differences of attitude towards BIM-adoption varies not only depending on the size of the company but also on its role played in the construction process and corresponding responsibilities.

It is noticeable that the use of BIM across SMEs varies among architects, engineers, general contractors and subcontractors (Forsythe, 2014). Small architectural and consultancy companies are more likely to equip themselves with Information and Communication Technology (ICT) that allows adapting to a new digital design practice (Forsythe, 2014). This brings up the question about who should deal with the managing and developing BIM technologies in the SMEs? Considering that BIM manager's role differs substantially from the traditional construction manager's role and the fact that small practices are limited with their access to resources, hiring a person responsible solely for BIM management turns out to be simply too expensive. However, Klaschka's case study of Poulter Architect's practice (2014) demonstrates that in the small-scale projects it is possible to combine traditional and BIM-related roles. The authors continue, the interviewed owner of the company declares that "the smaller scale of the projects I work on means that I can combine the roles of architect, lead consultant, and BIM manager. It also offers the potential to provide further services such as environmental analysis and materials scheduling". This implies how different the SMEs' project environment is compared to the large corporations.

Size of a construction company determines contexts and pressures facing it, hence the BIM-gap in the sector. A literature review carried out by Lu et al. (2008) discusses SMEs' different challenges in BIM transformation with reference to the role of the owner(s)/manager(s), company structure, resource limitations, and family ownership which form a specific business environment. However, the lesser scale of projects means that a company has this "safety net" of possibility to easily reverse out of early projects into CAD, in case of overwhelming difficulties (Klaschka, 2014). It creates an environment that is not strictly more challenging but presenting different challenges than in larger scale construction and those different challenges require a different approach.

Currently, there are many new advanced technologies being presented to the sector by software companies, and there are also many analyses being undertaken to get a better insight on how the sector is changing and is expected to change in the future due to general BIM implementation. Some research study focuses on criticizing the imperfections of BIM and suggests that higher resolution and more practically oriented approaches are needed for enhancing BIM implementation (Miettinen & Paavola, 2014). However, targeting and empowering the weakest link in an Integrated Design – ID framework (which concerns SMEs), as well as the BIM-gap phenomenon, is far from being popular investigated research problems (Forsythe, 2014). Every company's goal is to be competitive on the market and producing revenue, but since BIM-adoption in the SMEs is lower (unless an external intervention would kick), beginning a more extensive BIM implementation for SMEs will remain more resistant to the application of ICT. Therefore, they pursue with conventional construction processes for a longer period, and it leads to slowing down the sector's growth and BIM-adoption. In this perspective, the aim of the present research study is firstly to identify issues that cause the existing BIM-gap to emerge and secondly to investigate what actions can be undertaken with an attempt to reduce them towards enhancing BIM-adoption for the SMEs. The intention is to provide these companies with potential solutions that can enhance their productivity and reduce risks via the utilization of BIM-related technologies. The paper is structured with section 2, which summarizes the methodology for developing the results, whilst section 3 gives further detail of the analysis. Section 4 discusses the results, and finally, section 5 presents the conclusion and further research work.

2. Methodology

The methodology utilized in this research includes mixing of quantitative and qualitative research methods. It denotes a comprehensive data collection from various sources such as literature review, practitioners, websites, and through conducting online forum interviews to integrate different types of data and so more reliable interpretation of the results. In order to assure the trustworthiness of findings, the triangulation mixed method is used (Groat et al., 2002). As such, different types of data sources are utilized in order to offset the weaknesses.

What makes up for a significant part of this research is literature reviews focusing on BIM-adoption and implementation. In addition, the research methodology comprises the data collection from various experienced practitioners including Site Engineers, Construction Managers, Schedulers, Cost Estimators, BIM coordinators, Consultants, and Designers with an understanding of the on-site BIM implementation. The results are then categorized and analyzed in the form of a histogram through gathering the information about common covered issues in the literature. The categories are selected considering the coverage of the identified challenges in the literature with at least one or more of the relevant investigating barrios. Moreover, research involves a number of interactive interviews in the form of online forum discussions including an online survey, querying issues concerning adopting BIM in their practices as well as a review of relevant practitioners' opinions that found on the internet relevant to the same topic. This allows us to reach out to a wide range of practitioners around the globe (Poland, USA, Colombia), which contributes to the findings' universal character.

3. Analysis

Following the reviewed literature and the performed analysis, many of the sources present similar findings which can be categorized in specific categories including *motivation, knowledge, cooperation, software, skills,* and *costs*. Hereafter, the established parameters were verified through a consensus-based approach. In doing so, based on the specific challenges covered in each of the reviewed papers as well as the relevant introduced parameters, a subjective assessment scale (from 0 to 5, where 0 stands for "not mentioned" and 5 for "crucial") of the problems was undertaken (see *Table 1*). This helps us to structure an overview of the character and scope of the issues within BIM-adoption being faced by the SMEs, which subsequently contributes to the identification of what actions might bring improvement in the existing situation.

Table 1: Identification and evaluation of the challenges in BIM-adoption for SMEs

	Davies et al., 2017	Bargstädt, 2015	Migilinskas et al., 2013	Mäki & Kerosuo, 2015	Malacarne et al., 2018	Azhar, 2011	Miettinen & Paavola, 2014	Poirier et al., 2015a	Poirier et al., 2015b	Arayici et al., 2011	Dainty et al., 2017	Forsythe, 2014	Sebastian et al., 2009	∑
Motivation	4	0	4	0	0	0	4	4	5	4	4	4	2	35
Knowledge	3	0	2	0	1	2	3	2	3	3	4	1	2	26
Cooperation	3	0	5	4	2	5	3	2	3	3	0	4	0	34
Software	2	2	4	2	4	0	0	0	0	1	2	0	3	20
Skills	4	3	3	4	2	2	1	0	3	4	3	4	0	33
Costs	0	1	4	0	4	0	0	0	3	1	2	3	0	18

In the following, we use the identified categories (or lenses) in order to investigate adoption and implementation barriers.

Motivation - Even though the phenomenon of "the BIM hype" – a blind belief in future-oriented visions of the BIM's advantages (aka the "BIM utopia") – can be noticed throughout the AECO sector (Miettinen & Paavola, 2014). SMEs are characterized by a tendency of skepticism towards implementing this innovation (Dainty et al., 2017). Leaders of SMEs are often scared of implementing BIM due to that the evidence of positive Return on Investment (ROI) ratio is very difficult to obtain (Poirier et al., 2015a) and are also aware of risks that come with disruptive and radical innovation such as ROI.

Knowledge - Many of the listed challenges have a common denominator as misunderstandings, improper perceptions, lack of experience, topics that are insufficiently represented in research findings when it comes to BIM (Arayici et al., 2011; Dainty et al., 2017; Davies et al., 2017; Miettinen & Paavola, 2014).

Cooperation - Since BIM is an element of an ID schema, the mindset of trust and transparency and the principle of effective and open communication are also relevant in the BIM implementation process. Many companies struggle with changing their cooperation practices from the traditional approach to one that suits ID. The close collaboration of all the stakeholders starting as early as possible, assuring efficient bidirectional data flow, a correct division of BIM related tasks and responsibilities are one of the main cooperation issues that need to be dealt with and this inspired choice of the cooperation parameter (Azhar, 2011; Forsythe, 2014; Mäki & Kerosuo, 2015; Migilinskas et al., 2013).

Software - Software plays an important role in BIM implementation. There is a wide range of programs that can serve as the main tool for different project parties in this process. This allows for freedom of choice and from the business point of view assures competition between different software developing companies which have a positive impact on the product quality and pricing. On the other hand, this also introduces interoperability issues and creates a significant barrier to ensuring a fully circular and integrated process. Additionally, there is a need for some functionalities in certain contexts, such as small- and medium-sized contractors, that current software market does not satisfy (Malacarne et al., 2018; Migilinskas et al., 2013)

Skills - BIM-related methodologies require a certain set of skills from staff involved in a project. Proficiency in modeling and operating the BIM software is crucial for success but not easy to find in the market. Additionally, the "soft skills" of cooperating personnel are very important in ID. Many of the analyzed papers highlighted these and other skills as a significant barrier to BIM implementation (Arayici et al., 2011; Davies et al., 2017; Forsythe, 2014; Mäki & Kerosuo, 2015).

Costs - Especially in the context of SMEs, the surcharging costs concerning acquiring new software, hardware and time spent learning new skills can have a significant impact on the overall company's finances. This is an aspect that is very important from the perspective of a company that considers implementing this innovation (Forsythe, 2014; Malacarne et al., 2018; Migilinskas et al., 2013; Poirier et al., 2015b). In order to identify the scale and the relevant types of the barriers that lower SMEs BIM-adoption, the last column of Table 1 illustrates the importance of the described above categories that the sector might gain more from an attempt reducing their magnitude.

The category motivation has been considered and highlighted as a crucial one in most of the reviewed research papers. By good fortune, skepticism as well as confronting the innovative transformation obstacles (which are one of the main motivational barriers) are expected to be reduced with upcoming years (due to increased awareness) and by reducing the magnitude of the other obstacles. Lack of effective cooperation and BIM-related skills turns out to be the two other largest challenges. Insufficient knowledge of BIM processes and ICT principles can be considered a medium scale problem, subjected to considering that many of those barriers seem interconnected. More effective cooperation and a better skillset match of the project members (or a lower skill requirement) can be provided due to a decrease of misunderstandings (cooperation parameter), and more realistic perception of BIM (knowledge parameter). Additionally, enhancing and overcoming the skill barriers would also improve collaboration. This leads to a conclusion that focusing on overcoming skill and knowledge relevant challenges should have an echoing positive reaction on different issues as the implications of BIM implementation.

3.1 Information collected from Internet forums

In this subsection, we provide a few short examples of the information that were collected and analyses from internet forums. Due to the fact that most of the existing BIM-related forums focus on BIM-based software (i.e. Autodesk Revit), the data collection here has a narrow software focus.

Response from a user FBlome from www.revitforum.org. A self-employed residential architect from Menlo Park, California (USA) with many years of experience in the single-family housing sector

FBlome suggests that undertaking any initiatives which assume close collaboration between partners of a construction project is not plausible for the current state of this sector of the industry since it consists of many small businesses working independently that are not motivated to change their work ethic. “A few years ago,” as the respondent states, he took part in a design-build project with a contractor/developer building a large high-end home. A BIM consultancy company (with experience in dealing with tract and spec home developers – design once, build many) was hired which purpose was to provide a BoM (Bill of Materials). The conclusions drawn from that cooperation were as follows:

- Creation of an accurate BoM in Revit is extremely time-consuming, especially in case of dealing with complex structural nuances;
- There was not a single subcontractor willing to take advantage of the created BoM for their pricing and bidding which defeated the whole purpose of the initiative.

Different sources

(…) if you are serious about cost estimation you cannot do it inside Revit. the problem lies within the fact that Revit accounts for materials and the work associated with them. Example, laying brick might require the brick be washed before laying it, that activity cost money. Concrete formwork requires materials and installation. Revit does not have any idea about that. – user smashta

Excerpted from a discussion under a thread titled “What's the best way to generate quantity and cost estimates?” on augi.com forum. [“What's the best way”, 2011]

(…) I dislike moving between programs. This is unproductive, too. You have to learn multiple programs. In our case, there are Revit, Advance Steel, Civil3D, SOFiCAD and Inventor what should be learned to be productive. Why this is unproductive? Each program has its own User Interface, its own learning curve. And I even do not want to think over data exchange… – user m.steffannoe

Excerpted from a discussion under a thread titled “Measure in 3D” on autodesk.com forum. [“Measure in 3D”, 2016].

All online forum sources provide consensual data about the fact that there is much room for improvement of BIM utilization during project phases that are the most relevant to them. BIM software is considered to have great potential, but it is difficult to utilize it correctly at its current state due to many of the barriers mentioned in the literature. For example, the collected data proves that in Autodesk’s Revit there is a significant amount of space for improvement on various levels that could enhance the user experience by lowering the complexity of some tasks, i.e. major inefficiencies of the Autodesk Revit as extracted from the forums are as follows:

- QTO (Quantity Take-Off) and scheduling tools are considered inefficient by most;
- QTO tools suffer from many limitations for the user (filtering, handling of the finishes, handling

of some objects) which make them less applicable for precise measuring;
- Modeling and editing of certain elements are inefficient and time-consuming as a result. Forces to perform certain workarounds;
- Some Revit processes suffer from limited filtering options available;
- Interoperability with other software.

4. Discussion and results

In the last years, other researchers highlighted the significance of the investigation of BIM-adoption-related issues regarding SMEs. Dainty et al., (2017) claim that the endemic disadvantages that such companies face have been ignored in the policy process which – if not counteracted - is likely to increase the market differentiation. In their research, Miettinen & Paavola (2014) suggest that a well-documented investigation of BIM implementation within different contexts needs to be undertaken in order to assess problems and further challenges of developing the BIM use. This research attempts to take part in the aforementioned investigation.

The analysis model in the previous section reveals the challenges and their relative importance in shifting into BIM, especially in the context of SMEs. The last column of Table 1 allows making a general assessment about which of the analyzing parameters (challenges) play a more significant role in slowing down the process of BIM-adoption in the AECO sector in alignment with the surveyed literature. It is evident that the common skepticism attitude of SMEs and especially the contracting firms' representatives regarding BIM implementation is substantial.

n this consideration, the BIM-adoption barriers can be categorized in three groups concerning their scales including large-scale (motivation, cooperation, and skills), medium scale (knowledge), and small scale (software and cost-related challenges). This shows that although SMEs have significantly smaller investment capabilities in the sector, the financial aspect of a BIM transformation is not the biggest concern for these companies – on the contrary – it can be considered a minor obstacle in comparison to the rest of identified categories. Since associated software challenges are also less critical compared to others, it can result that software relevant aid for SMEs should not be excluded as possible support in BIM implementation for SMEs. In addition, focusing on the facilitation of collaboration processes and complexity reduction (skill requirement) by any means can be noticeably beneficial for the whole sector.

Software, skills & costs: Exploration of the BIM technology in the SMEs context proves that there is much room for improving its utilization in this sector, even more so, specifically on the contractors' end. Research results based on data collected from a wide range of sources demonstrate that among various factors BIM software is one of those that limit BIM-adoption on the AECO market and is correlated with different issues like skill and resource requirements. BIM software products, like Autodesk's Revit, as well as others, expand their toolsets rapidly to make them capable of creating more complex and demanding BIM models applicable to large-scale development projects. Since BIM software development is a business like any other, the product needs to satisfy the user's needs in order to sell and provide revenue. At the current state, the largest clients of those software development companies are the ones involved in the largest and most demanding of projects; hence the priority is put on satisfying this part of the sector. The SME sector must not be neglected with that regard.

However, BIM user's persona differs greatly depending on the part of the construction sector considered which results in the user's needs differing greatly throughout the large industry like this. The manifestation of that diversity can be observed when considering how many different software product propositions there are available on the market right now. The choice of BIM software is wide to such an extent that new consulting companies started to emerge which provide service of just researching and identifying BIM products fitting the needs provided by the client. Additionally, this situation works against the basic ID principle, namely the integration. Since BIM software is crucial in the process of switching from traditional construction to ID, the factor of the introduced stakeholder separation due to the utilization of numerous software platforms being a prerequisite of even a small-scale construction project works against this integration and should be minimized. Focusing on the reduction of the size of the required "BIM software starter-pack" for those at a BIM-infant state while still not forgetting about enhancing general interoperability of different software packages would contribute to enhancing BIM-adoption among SMEs.

Research results prove that an efficient BIM-software solution for SMEs requires putting more emphasis on different issues than in the case of large companies. SMEs working on small-scale projects do not encounter that much repetitiveness and scarcity of resources like cost, time, BIM-proficient staff and knowledge about alternative means of project delivery (like ID) which make smaller companies' BIM-use substantially different. Even though this sector constitutes a significant amount of the AECO industry the most popular BIM products on the market comprise of numerous solutions that SME users cannot fully take advantage of and lack simple solutions that could enhance BIM applicability greatly for small companies and consequently raise the BIM-adoption. More focus needs to be put on providing BIM-solutions that are less hardware-demanding, have a lower skill floor – the difficulty level of beginning the process of mastery of a specific computer program – and have a payment scheme that does not overburden smaller construction companies

Motivation, cooperation & knowledge: Other barriers, besides software-related, like motivation, cooperation and knowledge can be tackled with other means and enhance overall BIM implementation since all of the implementation barriers are correlated. Rising BIM awareness amongst smaller companies and fighting the belief that investing in BIM is profitable only for large companies is one of the ways that knowledge and motivation obstacles can be reduced. Klaschka's (2014) case studies serve as a good example of that since there is no believing without seeing when a businesses' future is at stake. Additionally, according to Alreshidi et al. (2017), BIM-related standards must not reflect the desires, issues, and concerns of specific groups (large companies) excluding others (SMEs). Inappropriate BIM-governance functions like a repellant to those of doubt. Undertaken literature review's results prove that the "BIM works only for large companies" a stereotype is wrong by providing real examples of SMEs gaining from BIM implementation, but those and other examples still need more publicity in order to help with a mindset change of the skeptics. Cooperating with stakeholders that are not willing to do so or lack either the skills or the knowledge of how it should be done cannot be optimal. Furthermore, software that does not fit into a project's context or scale or is just too expensive to implement exacerbates teamwork between the project's members. That is why the significance of the cooperation adoption barrier is mainly dependent on the scope of work put into dealing with the BIM transformation efficiently, with adequate preparation and the right team. Without those factors quality of teamwork suffers and can lead to piling up of BIM-related issues that can have the opposite effect to ensure the team of the validity of the decision to perform a BIM transformation.

Closing the BIM-gap: Closing the BIM-gap would provide many benefits to both SMEs and large construction companies. More small companies could get involved in demanding large-scale projects as sub-contractors and start implementing new ideas on other projects after taking part in an alternative project delivery method and utilizing modern technologies. Achieving that could expand their competences and range of provided services that would make those companies more resilient to construction market's fluctuations by better adaptation potential. On the other hand, large companies would get a wider range of competent sub-contractors to choose from when collecting the project team that can deal with a higher degree of complexity and more innovative workflows. All in all, the pace of the innovation adopting in the AECO industry would increase.

5. Conclusions and future work

This paper considered the common characteristics of various barriers that slow down the process of BIM-adoption in the AECO industry. Identification of these parameters allowed to create an analysis model which helped to get an overview of the collected data from the surveyed literature. Many of the barriers for enhancing the BIM-adoption in the market came out to be interconnected. This means that overcoming either of them can also cause in reducing another.

It is evident that close cooperation with practitioners when researching SMEs' BIM implementation is of great importance, likewise as isolation of this construction industry sector is one of the reasons for BIM-gap to emerge in the first place. Even though general BIM awareness on the market is high, BIM-gap awareness should be improved, and more attention should be given to it so as to market-wide BIM implementation can be accelerated and, hypothetically, it enhances the general construction sector's condition. From the Internet forum research, it was concluded that tailoring of the

BIM-software solutions to the needs of all building sector stakeholders plays a critical role in increasing the applicability of BIM-technologies for the SME sector. Further, software development should be undertaken, expanding its functionalities to avoid fragmentation of BIM processes when performing singular tasks in many different programs, reducing resource requirements (i.e. time) and skill requirement rooted in the level of complexity of certain procedures in BIM. The more repetitive and non-creative simple tasks can be automated, the more resources can be assigned to the other tasks.

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