The Benefits of and Barriers to BIM Adoption in Canada

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Abstract –

The adoption of Building Information Modelling (BIM) has influenced the traditional methods of planning, design, construction and operation of a physical asset. Organizations in Canada have adopted BIM to improve designs, foster stakeholder collaboration, and facilitate construction processes. To understand the extent of BIM adoption and implementation in the industry, the University of Toronto Building Tall Research Centre conducted two annual BIM surveys. The 2018 survey, which was conducted in collaboration with tBIMc, focused on the Greater Toronto Area. In 2019, the survey was expanded nation-wide with support from Canada BIM Council, BuildingSMART Canada, and local BIM chapters. In this paper, the results of the 2019 nation-wide survey are presented and benchmarked against those in the 2018 survey. An in-depth discussion of the perceived benefits of and barriers to adopting BIM in Canada are also provided. This study serves as one of the milestones of the BIM transition process in Canada and aims to present a detailed view of the role that BIM plays in the future of the industry.

Keywords –

Building Information Modelling; BIM; survey; benefits; barriers; benchmark;

1 Introduction

In the past decades, the construction sector has been seeking alternatives to enhance efficiency during project design, planning and construction phases from the traditional project delivery [1]. As a result, Building Information Modelling (BIM) is gaining interest in the building industry. BIM can be defined as the process of creating, managing and utilizing the shared digital representation of physical and functional aspects of any built asset by project stakeholders [2]. BIM can be a reliable basis for decision-making throughout the lifecycle of the asset [2].

Recognizing the prominent values of BIM, the implementation and uptake of BIM around the world have gained great momentum over the last decade. Leading countries have developed specific strategies and mandatory requirements for BIM adoption. An overview of global BIM implementations in terms of degree of regulatory mandate over the past 5 years is illustrated in Figure 1, where the size of the circle that represents each country is proportional to its population.

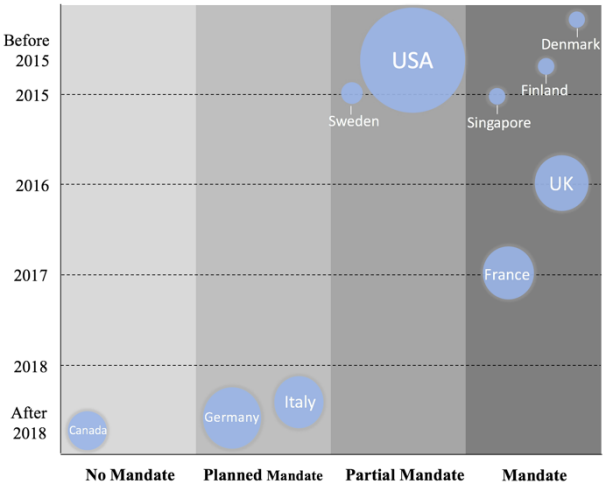

Figure 1. Global BIM Implementation Overview

Denmark was one of the earliest adopters of BIM in the world. They first mandated BIM for public projects in 2007 and extended the requirement to all projects in 2011 [3]. Similarly, Finland, Singapore, United Kingdom (UK) and France successfully mandated the full deployment of BIM in 2012, 2015, 2016 and 2017 respectively [3]. United States of America (USA) and Sweden represent partial BIM mandates, where BIM use was mandated only in certain regions and by specific government authorities [4]. Italy and Germany have specified plans to mandate BIM in 2019 and 2020, respectively [3].

In comparison to the aforementioned countries, Canada has neither an in-place BIM mandate nor clear national plans to implement BIM, and appears to be lagging behind the global trend of BIM adoption [5]. To better understand the extent of BIM adoption and implementation in the Canadian architecture,

engineering, and construction (AEC) industries as well as the issues in the current BIM adoption, the Second Annual BIM Survey was conducted in 2019 as a continuation of the First Annual BIM Survey in 2018 [6,7]. In collaboration with Canada BIM Council, BuildingSMART Canada, and local BIM chapters, the survey was disseminated across Canada and over 300 respondents participated this year. In this study, major findings obtained from the Second Annual BIM Survey are presented, along with benchmark analyses for the 2018 survey. The contribution of this study is to provide a holistic perspective of the adoption and implementation of BIM in Canada, with emphasis on the perceived benefits and barriers in the AEC industry.

2 Benefits of and Barriers to BIM Adoption

Compared to traditional project delivery methods, BIM brings many benefits and opportunities in the various project phases, namely, project design, construction and operation [1]. Major benefits identified in the project design phase include clash detection, enhanced visualization, cost estimation, design simulation, and automated code compliance checking [8,9,10]. During construction, BIM facilitates scheduling, activity sequencing, progress tracking, site safety assessment, and site logistics planning [11,12]. For the project operation phase, facility managers benefit from the information stored in the BIM database when performing space planning, facility maintenance, and refurbishment [13,14]. Finally, improved collaborations among stakeholders throughout the project life cycle can be achieved by adopting BIM [15,16,17].

Despite the numerous benefits and opportunities of BIM implementation, barriers and challenges were identified in previous research, which can be categorized into five major aspects, including technical, legal, cultural, financial and managerial [18]. Regarding BIM technologies, pertinent technical problems such as software compatibility were still unsolved. Some of the legal issues that hinder the adoption of BIM include stakeholders' liabilities on the accuracy and quality of data embedded in BIM models [5]; lack of regulations or guidelines on resolving any dispute that might arise due to BIM implementation [18]; intellectual property rights issues such as model ownership, copyright and authorization of model usage [19]. Cultural issues associated with BIM adoption that are most frequently mentioned by researchers include resistance to change and inadequate coordination among project stakeholders [18]. Financial barriers refer to the high initial investment in BIM technology [20], and the uncertain rate of return on investment [21]. Managerial barriers mainly come from the lack of confidence in BIM by management in an organization due to significant changes required in design phase workflow, project delivery methods [22], as well as software and hardware [23].

Successful implementation of BIM requires users to understand the values and issues associated with the technology, such that benefits can be reaped, and barriers can be eliminated. In addition, support and guidance from government bodies and related organizations would further speed up the adoption process [18].

3 BIM Surveys

To understand the status quo, barriers, and trends of BIM adoption in the AEC industry, several countries and organizations have conducted BIM surveys over the last decade.

3.1 Global BIM Surveys

In 2011, UK published its First National BIM Survey for understanding BIM adoption and implementation in the country. The National Building Specification (NBS), in collaboration with the Royal Institute of British Architects and the UK BIM Task Force, has been the main driving force for designing, collecting, and analyzing the surveys. Eight national reports have been published by NBS. The style and design of the UK national surveys questions were varied and adjusted throughout the years. For instance, the 2011 and 2012 national survey comprised a comprehensive list of questions, but the result analyses were relatively simple and straight-forward [24,25]. From 2013 onwards, the questions were categorized into sections, namely, BIM Experience, BIM and Government, as well as Attitudes toward BIM. In addition, more in-depth analyses and discussions on the survey results were included [26]. Simple comparisons with previous years' results were provided in the 2014, 2015 and 2016 BIM reports, and trends were identified [27,28,29]. Due to the launch of the UK's national BIM mandate in 2016, the main focus of the 2017 survey was shifted to examine the organizational engagement level of BIM implementation in the industry [30]. The latest 2018 NBS survey was similar to the previous one, with the emphasis on understanding the effect of government mandates and associated strategies [31].

In addition to the national BIM reports, NBS conducted two international BIM surveys in 2013 and 2016. Along with UK and Canada, New Zealand and Finland participated in the 2013 international survey while Denmark, Japan, and Czech Republic took part in 2016. There were only 78 and 127 respondents from Canada in the 2013 and 2016 international BIM surveys. The structure and design of the surveys were similar to the national surveys but significantly fewer questions were included in the international ones. Only common

and applicable questions were selected, and benchmark analyses among participating countries were presented in the two international BIM reports [32,33].

3.2 Local BIM Survey

In 2017-18, and in collaboration with the Toronto BIM Community (tBIMc), researchers from the University of Toronto Building Tall Research Centre conducted the First Annual BIM Survey to analyze BIM adoption in the Greater Toronto Area (GTA). Questions in the UK survey were adopted to facilitate benchmark analyses [7]. More than 250 respondents participated in the survey and a complete report of the key findings from the first annual survey was published in April of 2018 [6,7]. This survey serves as the baseline for BIM implementation in the Canadian market. As a pilot study, the first BIM survey was well-received by industry professionals and the results provided useful benchmarking indicators for future studies.

4 Second Annual BIM Survey

The Second Annual BIM Survey was a continuation effort. The goal of the 2019 survey was to collect a comprehensive understanding of BIM implementation from coast to coast in Canada.

The majority of questions for the Second Annual BIM Survey were adopted from the first survey with a few additional questions related to BIM application across Canada. An overview of the survey questions is presented in Table 1. Many of these questions had subsections, resulting in over 100 individual questions. The survey was structured into three sections: General Information, BIM Experience, and, Resources and Future of BIM. The demographics, background, and company information of the respondents were collected in section 1. Then, participants were asked to share their BIM experiences, such as the level of familiarity with BIM technology, the functionality of BIM, and perceived benefits and barriers for adopting BIM in project workflow. Finally, insights and opinions on BIM resources and the future trend of the construction industry were gathered in the last section.

Table 1. Overview of Survey Questions

Section 1: General Information
1. Which of these better explains your main role?
2. Years you been working in your discipline?
3. What is your age?
4. In what province is the office you primarily work?
5. In what city are you currently working?
6. How would you describe your organization type?
7. How many employees are there in your organization?
8. Where is your organization doing most work?
9. Which project types have you participated last year?
10. How familiar are you with BIM?
11. Which statements best describes your organization?
Section 2: BIM Experience
12. Ever involved in the following projects last year?
13. Level of confidence in BIM knowledge and skills?
14. What is your opinion on BIM-related beliefs?
15. Have you ever adopted BIM for projects?
16. What % of projects have you used BIM last year?
17. Number of parties you share BIM with per project?
18. What are your thoughts on Open BIM?
19. Which tools did you mainly use last year?
20. What do you use BIM for?
21. What are the main barriers to using BIM?
22. What is your opinion on the BIM benefits below?
Section 3: Resources and Future of BIM
23. Which sources of BIM information will you use?
24. Which Canadian BIM resources are you aware of?
25. How likely are the technologies to have significant influence on the industry over the next 10 years?

The Second Annual BIM Survey was first opened in October 2018 at a Toronto BIM Community event and closed in late February of 2019. The survey was promoted via social media channels and online platforms. It was also distributed through CANBIM and buildingSMART networks, Canada's two national BIM organizations. To further increase the number of participants for the survey, quick response (QR) cards that linked to the online survey were disseminated to AEC professionals across Canada. As Canada is bilingual, the survey was offered in both French and English.

5 Results and Discussions

In this section, an overview of the survey demographics will first be presented. The perceived benefits and barriers are identified from the survey and discussed in detail. Benchmarking analyses of the 2019 survey against the 2018 survey is also presented.

5.1 Demographics

The demographics of respondents for the Second Annual BIM Survey are shown in Figure 2. Of the 398 responses received, more than half (64%) are from Ontario (ON), perhaps because the survey was first launched and promoted in Ontario. Also, the BIM community in the Greater Toronto Area is very active

compared to other metropolitan centres in Canada. Response rates from Alberta (AB), British Columbia (BC), Quebec (QC) and outside of Canada are at 15%, 8%, 5%, and 5% respectively. A few industry professionals from Nova Scotia, Manitoba and Saskatchewan participated in the survey. For the scope of this paper, only responses from the top four participating provinces, namely, ON, AB, BC, and QC are included in the following discussions.

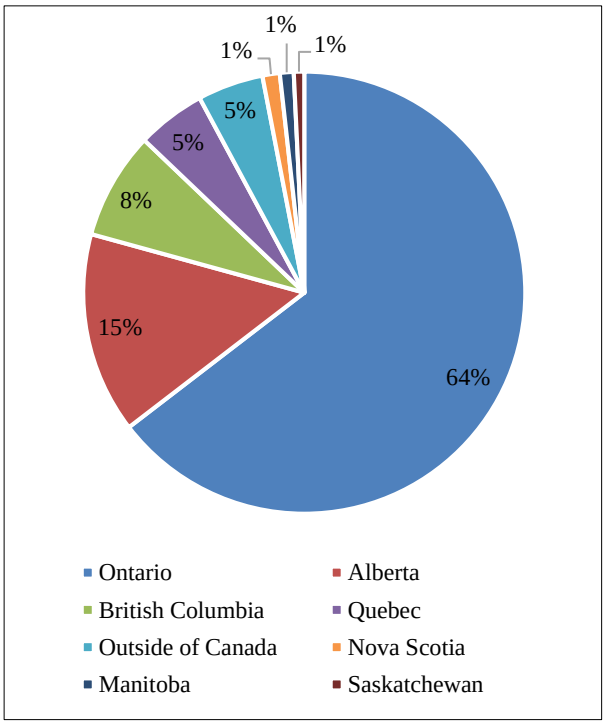

Figure 2. Demographics of 2019 Survey

5.2 Perceived Benefits of BIM Adoption

Question 22 focused on the perceived benefits of using BIM, where respondents were asked to agree or disagree with the statement that adopting BIM can:

- BN1: Improve visualization
- BN2: Bring cost efficiency
- BN3: Enable international collaboration
- BN4: Increase profitability
- BN5: Increase speed of delivery
- BN6: Enable new types of project

Figure 3 indicates over 80% of respondents agree that adopting BIM can bring visualization benefits (BN1). Second to visualization is the cost efficiency (BN2) that BIM can potentially provide in a project, especially if BIM is implemented with the support of all project stakeholders. The benefits from BN3 to BN6 also received over 50% agreement, whereby respondents generally agree with the perceived benefits of BIM.

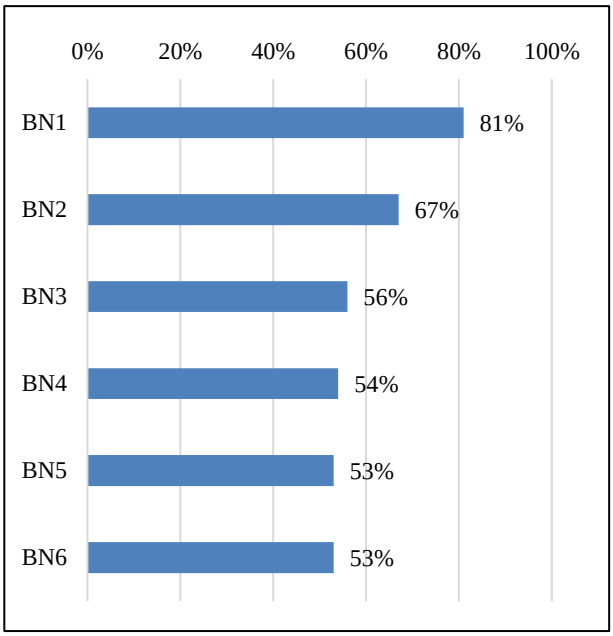

Figure 3. Overall Perceived Benefits of Respondents

Based on the demographics of respondents, Analysis of Variance (ANOVA) was adopted to analyze the differences among the four provinces with the $p<0.05$ threshold for rejecting the null hypothesis. ”Strongly Agree” and “Agree” were coded as “1” and “Unsure”, “Disagree” and “Strongly Disagree” were coded as “0”. Table 1 shows the P-values that were output when ANOVA tests were run for the six perceived benefits. All benefits (BN1-BN6) have P-values over 0.05, which means that there was no statistically significant difference towards the perception of the six BIM benefits among the four provinces. This shows a positive sign for the industry as the various benefits of BIM adoption are consistently perceived by different regions across Canada.

Table 1. P-Values for the Six Benefits

	BN1	BN2	BN3	BN4	BN5	BN6
P	0.447	0.673	0.766	0.594	0.792	0.680

5.2.1 Comparison of 2018 and 2019 Perceived Benefits in GTA Only

BIM users and non-users were identified in both years: BIM users are those who have used or currently use BIM on projects, and non-users are those who have basic BIM knowledge but do not use BIM on a regular basis [7]. Responses from the GTA region in 2019 were compared

to respondents in 2018, across the six identified benefits as shown in Figure 4. Comparison of 2018 and 2019 GTA Surveys, users have stronger beliefs than non-users such that users' experience provides better insights into the perceived benefits for adopting BIM in projects, workflow, and industry. Three benefits (BN1, BN2, and BN4) are well-perceived (over 80% agreement) by BIM users in both 2018 and 2019 surveys. Non-users generally have an increase in beliefs in the perceived benefits, except for visualization (BN2). However, the slight drop in visualization is not significant. The general increase in understanding for BIM benefits for users and non-users shows promising results for the future of the AEC industry.

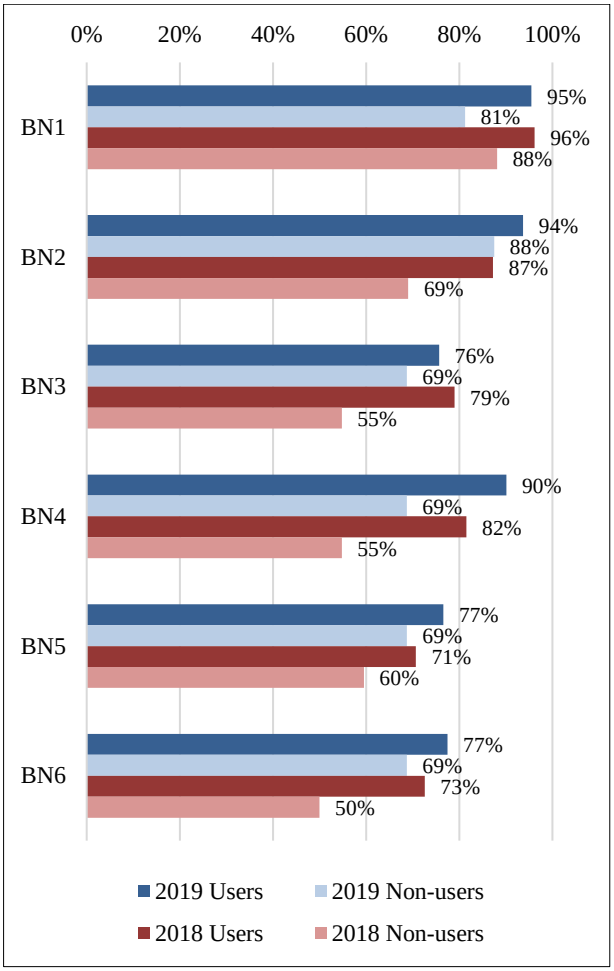

Figure 4. Comparison of 2018 and 2019 GTA Surveys

5.3 Perceived Barriers to BIM Adoption

Question 21 examined the barriers to BIM adoption. Respondents were asked to select the barriers they encountered from a list:

- BR1: Resistance to change
- BR2: Lack of knowledge/skill
- BR3: Software learning curves
- BR4: Lack of training
- BR5: Lack of mandate
- BR6: No client demand
- BR7: Lack of collaboration/cooperation
- BR8: Legal issues
- BR9: Doubts on return on investment
- BR10: Lack of perceived benefits

Based on the responses, top barriers to BIM adoption in ON, AB, BC, and QC are presented in Figure 5. Resistance to change (BR1) is the number one barrier throughout four provinces, which might imply that the local construction industry is ready for BIM implementation but there are still a lot of people refusing to embrace the technology. Lack of knowledge/skill (BR2) is another common barrier identified to BIM adoption. It was interesting to see that this barrier is more prominent in BC and QC comparing to AB and ON. In terms of software learning curves (BR3) and lack of training (BR4), the responses from BC, AB, and QC are rather close at around 50%. The results from ON for BN3-BN5 were significantly lower than the rest provinces, which might indicate that there are comparatively more software training opportunities available and more support from public authorities towards BIM adoption in Ontario.

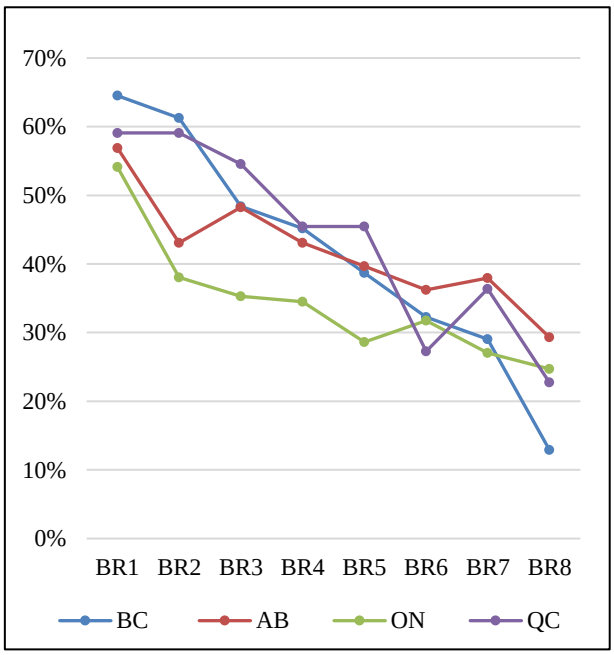

Figure 5. Comparison of Perceived Barriers in ON, AB, BC, and QC

In addition, around 30% of respondents agreed on the barriers of lack of client demand (BR6) and lack of collaboration/ cooperation (BR7). This indicates that joint efforts from the government, project stakeholders and clients are important but not crucial to ensuring BIM adoption. Lastly, legal issues (BR8), including ownership, liability, and licensing, are considered as a greater barrier in AB, ON and QC compared to BC.

5.3.1 Comparison of 2018 and 2019 Perceived Barriers in GTA Only

Top barriers to BIM adoption in GTA are presented in Figure 6. Comparing the barriers identified in 2018 and 2019, a growing trend in BIM adoption can be identified in the GTA region. In 2019, significantly more respondents are able to see the benefits of BIM and fewer are having doubts on the Return on Investment (ROI) of implementing BIM comparing to 2018. Even though a lack of mandate is perceived to be less of a barrier in 2019, industry professionals are seeing more demand from clients (as indicated by the reduction in No Client Demand) and starting to develop their own BIM Execution Plan within their company. With wider BIM implementation in the GTA region this year, barriers including lack of training, software learning curves and resistance to change are becoming more prominent.

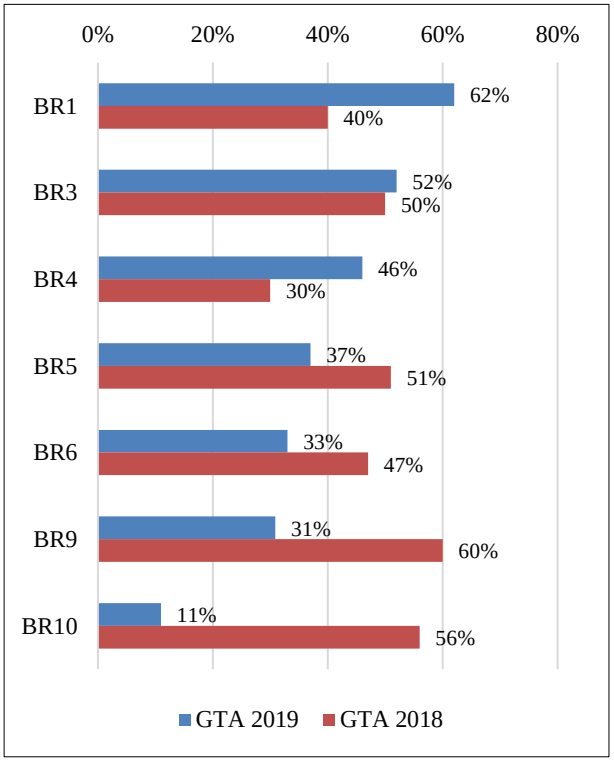

Figure 6. Comparison of 2018 and 2019 GTA Surveys

6 Conclusion and Future Work

Understanding the local and national barriers to innovation and new technologies can help streamline the adoption process. This paper first reviewed the global status of BIM implementation, worldwide initiatives on BIM surveys as well as some of the potential benefits and barriers in BIM adoption in literature reviews. Local BIM survey initiatives including the First Annual BIM Survey in GTA and the Second Annual BIM Survey in Canada were introduced in detail. The goal of the surveys was to capture and document the adoption status of BIM in the Canadian AEC industry.

In this paper, special attention was paid to the perceived benefits and barriers to BIM implementations. The complete survey results and analysis for the Second Annual BIM Survey will be published online at the Building Tall Research Centre (buildingtall.utoronto.ca) and tBIMc (tbimc.ca) websites. This BIM survey initiative will be repeated on an annual basis in the future to identify and monitor the trend of the BIM adoption in Canada, which serves as a milestone in the BIM transition process in the Canadian AEC industry.

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