International Journal of Architectural, Civil and Construction Sciences
ISSN: 2415-1734
Vol:9, No:5, 2015

The Status of BIM Adoption on Six Continents

Wooyoung Jung, Ghang Lee

***Abstract*—**This paper reports the worldwide status of building information modeling (BIM) adoption from the perspectives of the engagement level, the Hype Cycle model, the technology diffusion model, and BIM services. An online survey was distributed, and 156 experts from six continents responded. Overall, North America was the most advanced continent, followed by Oceania and Europe. Countries in Asia perceived their phase mainly as slope of enlightenment (mature) in the Hype Cycle model. In the technology diffusion model, the main BIM-users worldwide were "early majority" (third phase), but those in the Middle East/Africa and South America were "early adopters" (second phase). In addition, the more advanced the country, the more number of BIM services employed in general. In summary, North America, Europe, Oceania, and Asia were advancing rapidly toward the mature stage of BIM, whereas the Middle East/Africa and South America were still in the early phase. The simple indexes used in this study may be used to track the worldwide status of BIM adoption in long-term surveys.

***Keywords*—**BIM adoption, BIM services, Hype Cycle model, Technology diffusion model.

I. Introduction

BUILDING INFORMATION MODELING (BIM) has been adopted in many countries since the early 2000s, and many researchers and institutes have attempted to measure the status of BIM adoption because knowing this is critical in evaluating and solving problems in BIM implementation [1]-[4]. The SmartMarket Report series has annually reported the BIM adoption status in various regions since 2007 [5]-[11]. Yonsei University in Seoul, South Korea has also been measuring the status of BIM adoption in South Korea every other year since 2008 [8], [12], [25]. In addition to these, numerous surveys have been conducted to measure the status of BIM adoption in a specific country [1], [5]-[18] or of a specific domain [10]. Interestingly, these surveys have been using similar indexes, such as BIM adoption rate, the percentage of expert BIM users, and years using BIM, as if they had all implicitly agreed to use these. Despite the similarities between the indexes used in previous surveys, each survey focused mainly on a single country or an industry at a time except for the 2013 SmartMarket Report, which compared the BIM adoption status of ten countries on four continents [10], and the 2013 NBS international report, which compared four countries on three continents [19].

This study aims to report the status of worldwide BIM adoption with an expanded scope and additional indexes. In terms of scope, it focuses on all six continents in the world instead of focusing on one or several specific countries. In terms of measurement index, it uses the Hype Cycle model, the technology diffusion model, commonly used models in depicting the adoption status of a technology, and BIM services (also known as BIM uses) in addition to the typical BIM adoption indexes used in previous studies.

Wooyoung Jung is with the Yonsei University, Seoul, Republic of Korea (e-mail: jwyoungs@naver.com).

Ghang Lee, Ph.D. is with the Yonsei University, Seoul, Republic of Korea (corresponding author to provide phone: +82 2 2123 7833; e-mail: glee@yonsei.ac.kr).

II. Previous Studies

The status of BIM adoption has been consistently evaluated and measured in many regions. The first attempt was the SmartMarket Report in 2007 [5]. Since then, the SmartMarket series, NBS reports, BIM surveys, and others have reported their domestic or international market status. They mainly surveyed, for example, respondents' experience with BIM, perception about benefits and future importance of BIM, frequently used BIM software applications, and planned BIM investments [5]-[18]. As described above, "BIM adoption rate," "depth of implementation," "level of proficiency," and "years of using BIM" are consistently used as indexes for measuring the status of BIM adoption throughout these surveys, as the first index reflects the overall status of BIM adoption and the others the engagement level of BIM users. According to these surveys, the adoption rate and experience level of respondents in North America rapidly increased from 2009 to 2012, and the respondents from South Korea, Oceania, and North America predicted that their depth of BIM implementation would increase in the near future. The BIM adoption rate in the UK has also steadily increased from 31.0% in 2010 to 54.0% in 2013, and UK users became more knowledgeable and skillful in BIM according to the NBS reports [16].

However, many reports and surveys concentrated on one country [1], [2], [5]-[18] and each survey was conducted at a different period, so it is difficult to compare their status. Although the 2013 SmartMarket Report [10] surveyed 10 countries at the same time, the respondents were restricted to general contractors. Another international report, the 2013 NBS report [19], only investigated the UK, Canada, Finland, and New Zealand.

This paper surveys BIM adoption on six continents and reports the worldwide BIM adoption status using the three indexes "depth of implementation," "level of proficiency," and "years of using BIM," which have constantly been used in previous surveys for analyzing the engagement level of BIM users. In addition, it uses two more frequently employed technology adoption models, namely, the Hype Cycle model [20], [21] and the technology diffusion model [22]. The former indicates the phase of technology adoption and the latter describes the major user of a technology. Lastly, we analyze the use of BIM services, surveyed [23], and defined in the BIM

Project Execution Planning Guide [24], to understand the use frequencies and types of BIM services by BIM adoption status. With the expanded scope of a BIM survey, this paper aims to provide readers with a broad understanding of the current status of worldwide BIM adoption.

III. Methodology

An online survey was used in order to collect BIM experts' responses. The survey was distributed in five languages, Korean, English, French, Spanish, and Chinese, to a total of 1,310 potential respondents. The potential respondents included 159 authors of 71 papers found via the keyword "BIM" on www.sciencedirect.com (1997–2014) and scholar.google.com (2004–2014) and 1,151 members who were registered as "BIM Manager," "BIM Specialist," "BIM Coordinator," or any career related with "BIM" in the BIM Experts group or in the BIM + Revit MEP group on LinkedIn (2003–2014). This survey was conducted from May 22 to July 2, 2014. We received 168 responses out of 1,310 solicitations (11.5%). Among 168 responses, 150 responses were valid (89.3%). By continent, 29 responses were from North America, 40 from Europe, 47 from Asia, 12 from Oceania, 15 from the Middle East/Africa and 7 from South America. Table I shows the countries where the respondents worked and distribution of the countries into continents. Two representative countries responded in North America, 17 countries in Europe, 7 countries in Asia, 8 countries in the Middle East/Africa, 5 countries in South America.

TABLE I
The Countries Included in Each Continent

Continent	Countries included
North America	U.S., Canada
Europe	Netherlands, France, Italy, Finland, Sweden, Denmark, U.K., Russia, Iceland, Portugal, Turkey, Germany, Spain, Belgium, Poland, Slovenia, Swiss.
Oceania	Australia, New Zealand
Asia	Republic of Korea, India, China (Hong Kong included), Philippines, Taiwan, Singapore, Thailand
The Middle East/Africa	Saudi Arabia, Egypt, Lebanon, Jordan, Iran, UAE, South Africa, Qatar
South America	Argentina, Mexico, Brazil, Chile, Costa Rica

In this survey, we used the engagement level "depth of implementation," "level of proficiency," and "years of using BIM" and excluded "adoption rate" because the adoption rate must include responses from non-BIM users in the survey pool, whereas the other indexes focus on BIM users. The "depth of implementation" is measured in a ratio scale ranging from 0.0% to 100.0%, with a 5.0% increase. The level of proficiency is categorized as "beginner," "moderate," "advanced," and "expert." The year of using BIM is measured as an integer number.

The Hype Cycle model and the technology diffusion model were also employed for understanding the BIM status via perceptions of technology (BIM) phases and major BIM users. Also, a list of frequently employed BIM services Penn State University proposed was also applied not just to learn about frequently used BIM functions but to compare BIM services by BIM adoption phase [24] Also, the statistical results will be compared in these models and in BIM services. The Hype Cycle model, introduced in 1995, has been widely utilized for measuring the maturity and potential of a technology. This model represents a common technology adoption pattern when an industry adopts a new technology. At the beginning, new technology generates interest from the press and industry (technology trigger). Then, augmented expectation even exceeds the reality (peak of inflated expectations). However, the expected barrier of reality appears higher than as thought by technology adopters, so general expectation lessens (trough of disillusionment). Some early adopters with patience begin to overcome obstacles and figure out how this technology can be utilized (slope of enlightenment). With the settlement of productivity and benefits, adoption increases (plateau of productivity). The first and second phases are generally regarded as "early" phase, the third as "moderate," and the fourth and fifth as "mature" and "very mature" We use the percentage of users in the fourth and fifth phases in judging the status of BIM adoption.

The technology diffusion model determines which type of user is the major user of a new technology [22]. This model categorizes technology users into five groups: innovators (the first 2.5% of all technology users), early adopters (an additional 13.5%), early majority (an additional 34.0%), late majority (an additional 34.0%), and laggards (the last 16.0%). A new technology diffuses from innovator to laggard according to the technology diffusion model.

Lastly, we surveyed the status of BIM services [24] as another potential index for understanding the BIM adoption level. Reference [24] demonstrates 25 BIM services and divides them into "Primary BIM services," and "Secondary BIM services". In this survey, 14 of "Primary BIM services" were included (Existing Conditions Modeling, Cost Estimation, Phase Planning, Programming, Site Analysis, Design Review, Design Authoring, Energy Analysis, 3D Coordination, Site Utilization Planning, 3D Control and Planning, Record Model, Maintenance Scheduling, and Building System Analysis). Our assumption is that common BIM services may vary depending on the BIM adoption level. In other words, the more varied the BIM services are, the higher the status the BIM implementation is.

We conducted a survey that included these three commonly used BIM status indexes, two technology adoption models, and BIM services. The next section describes the survey results.

IV. Survey Results

A. The Engagement Level

As mentioned earlier, we used three indexes for the engagement level: "depth of implementation," "level of proficiency," and "years of using BIM."

TABLE II
THE AVERAGES AND STANDARD DEVIATIONS OF THE ENGAGEMENT LEVEL

	North America	Europe	Asia	Oceania	The Middle East/Africa	South America
Year (stdv)	8.5 (5.3)	5.3 (3.2)	4.9 (2.9)	7.7 (3.5)	5.9 (3.7)	3.4 (1.0)
Depth (stdv)	73.0% (29.4)	55.9% (35.0)	46.4% (33.2)	65.5% (34.6)	60.0% (36.7)	55.7% (33.1)
Proficiency	82.1%	75.0%	46.3%	81.8%	80.0%	71.4%

Year: the average years of using BIM
Depth: the average depth of implementation
Proficiency: the ratio of users with "advanced" and "expert" level
Stdv: standard deviation

Table II represents the results. North America outperformed other continents in every index. Among respondents, 24.14% had more than 10 years of experience and 42.9% evaluated their skills at the "expert" level. The depth of implementation was over 75.0%. Moreover, 51.7% of respondents had applied BIM to over 90.0% of their projects.

Oceania followed right behind the first one. Their experience and proficiency levels were slightly less than North America: 25.0% of respondents had more than 10 years of experience, and 27.3% applied BIM to over 90.0% of their projects.

The Middle East/Africa was third. They have used BIM for 5.9 years on average, 60.0% of projects applied BIM, and 80.0% of users evaluated themselves as having an "advanced" or "expert" level of proficiency. Considering that the majority of BIM users in the Middle East were at the "beginner" level and in the "early adoption" phase in the 2011 survey [17], it has achieved rapid development in terms of engagement level.

Asia experienced BIM for a longer period of time than South America, who had the shortest period of experience, but Asia's other indexes were lower. In terms of skill, Asia was the only continent that did not have more than 70.0% "advanced" and "expert" users. Also, depth of implementation was the lowest (46.4%).

According to the results of the engagement level, North America, Oceania, and the Middle East/Africa were the more advanced countries and Asia and South America were less advanced.

B. Hype Cycle Model.

We have also analyzed the results from the Hype Cycle model. Fig. 1 shows the results of each continent regarding the Hype Cycle model. As analyzed in the engagement level, North America recognized its phases of technology adoption more highly than others. Although some differences were detected, Europe, Oceania, and Asia demonstrated similar results: the "slope of enlightenment" phase was the most selected—over 50.0% thought that they were in the "slope of enlightenment" and "plateau of productivity" phases. The Middle East/Africa showed evenly distributed answers, except the third choice, which had no replies. South America indicated that the first phase was the most selected (50.0%).

Each continent had its own most developed field (Fig. 2). Although the construction phase was the most developed in North America (75.0% fourth and fifth phases), 65.0% answered that their Hype Cycle phase in the design phase was in the fourth and fifth phases. According to the SmartMarket Report series, Asia used BIM widely in the construction phase [8], [10]: i.e., the construction phase was in "mature" phase of BIM adoption. The level of BIM use in Europe, Oceania, and the Middle East/Africa was most advanced during the design phase. Especially, 85.7% of respondents in Oceania perceived that the use of BIM during the design phase was in the fourth and fifth phases of the Hype Cycle model. On the other hand, 30.0% of respondents from the Middle East/Africa and 66.7% from South America perceived that their BIM adoption status was in the "early phases."

C. Technology Diffusion Model

Fig. 3 shows the results that represent how every respondent perceives major BIM users. Overall, 41.2% of respondents answered that the "early majority group" was the major BIM user. North America also perceived that the "early majority group" primarily used BIM (50.0%). Oceania and Asia were similar. On the other hand, the Middle East/Africa and South America's overall BIM users were the "early adopter group." South America had the same percentages of the "innovator" and the "early majority group," but the majority of responses were in the "early adopter group."

D. BIM Services

We also investigated the frequencies of BIM services on each continent, as shown in Fig. 4. This analysis was based on the assumption that when the status of BIM adoption is advanced, users apply for more functions. Generally, "3D coordination," "cost estimation," "existing conditions modeling," and "structural analysis" were widely used. It seems that these functions apply to multiple construction phases and have therefore been widely used. Some deviations existed, but it seems clear that if a group was advanced, more BIM services were applied. "Record modeling," "maintenance scheduling," and "building system analysis" for the operation phase remained in the lower ranks among all BIM services, but even a relatively high number of North Americans used these low-ranked BIM services. The average of the frequency of overall BIM services was 65.3% in Europe and 60.3% in Oceania. Europe used "cost estimation" more widely than Oceania; Oceania employed "existing conditions modeling" and "design authority." Asia and the Middle East/Africa similarly employed BIM services overall, using "3D coordination" and "design authoring" most widely. On the other hand, South America used "phase planning" and "site analysis."

Overall, the rankings among continents were quite similar in every approach. North America was the most developed and South America was the least developed. However, the results

from the engagement level, the Hype Cycle model, and the technology diffusion model in Asia and the Middle East/Africa were different. Asia had the lower engagement level than the Middle East/Africa, but Asia perceived their technology in the "mature" phase.

	Overall	*North America*	*Europe*	*Oceania*	*Asia*	*Middle East & Africa*	*South America*
Technology Trigger	11.4%	0.0%	11.1%	10.0%	9.5%	28.6%	50.0%
Peak of Inflated Expectations	2.6%	3.7%	6.7%	0.0%	6.3%	20.0%	0.0%
Trough of Disillusionment	20.0%	7.4%	22.2%	20.0%	28.6%	0.0%	33.3%
Slope of Enlightenment	38.6%	48.1%	33.3%	40.0%	42.9%	28.6%	16.7%
Plateau of Productivity	21.4%	40.7%	22.2%	30.0%	4.8%	35.7%	0.0%

Fig. 1 Perceived status of BIM adoption in the Hype Cycle model

	North America	**Europe**	**Oceania**	**Asia**	**Middle East & Africa**	**South America**
The most developed phase	Construction	Design	Design	Construction	Design	Construction
Technology Trigger	5.0%	13.6%	14.3%	12.1%	30.0%	33.3%
Peak of Inflated Expectations	10.0%	13.6%	0.0%	24.2%	10.0%	33.3%
Trough of Disillusionment	10.0%	13.6%	0.0%	12.1%	10.0%	0.0%
Slope of Enlightenment	40.0%	22.7%	42.9%	45.5%	30.0%	0.0%
Plateau of Productivity	35.0%	36.4%	42.9%	6.1%	20.0%	33.3%

Fig. 2 Each continent's most developed phase in the Hype Cycle model

	Overall	*North America*	*Europe*	*Oceania*	*Asia*	*Middle East & Africa*	*South America*
Innovators	7.4%	7.7%	8.6%	0.0%	4.9%	7.1%	33.3%
Early adopters	30.9%	26.9%	37.1%	40.0%	22.0%	42.9%	33.3%
Early majority	41.2%	50.0%	34.3%	50.0%	43.9%	28.6%	33.3%
Late majority	16.2%	15.4%	20.0%	10.0%	19.5%	14.3%	0.0%
Laggards	4.4%	0.0%	0.0%	0.0%	9.8%	7.1%	0.0%

Fig. 3 Perceived major BIM user in the technology diffusion model

	Overall	*North America*	*Europe*	*Oceania*	*Asia*	*Middle East and Africa*	*South America*
3D Coordination	85.0%	95.5%	92.9%	100.0%	70.3%	91.7%	60.0%
Cost Estimation	75.0%	95.5%	92.9%	66.7%	56.8%	58.3%	80.0%
Existing Conditions Modeling	74.3%	81.8%	60.7%	88.9%	67.6%	66.7%	80.0%
Design Authoring	63.4%	63.6%	71.4%	88.9%	73.0%	83.3%	0.0%
Structural Analysis	60.0%	90.9%	78.6%	88.9%	51.4%	50.0%	0.0%
Maintenance Scheduling	30.1%	54.5%	57.1%	33.3%	18.9%	16.7%	0.0%
Building System Analysis	33.4%	72.7%	53.6%	11.1%	37.8%	25.0%	0.0%

Fig. 4 Use frequencies of BIM services used in each continent

V. Conclusion

We conducted a survey using four different sets of indexes: engagement level, the Hype Cycle model, the technology diffusion model, and BIM services. Each method evaluates different issues (percentage of BIM projects, expertise, years of using BIM, technology phase, major user, and use), but basically, the purpose was the same. As a result, North America apparently ranked as the most advanced continent in every approach. Oceania and Europe were considered the next most advanced and were especially strong in the design phase. Although Asia ranked 5th amongst 6 continents in the engagement level and BIM services, it perceived its status of BIM adoption similarly to other advanced continents. On the other hand, in the Middle East/Africa, the engagement level was third and even quite similar with the first and second, but they still considered their status of BIM adoption to be in the "beginner phase." Lastly, South America was the lowest.

This paper has the limitation of having a relatively small number of responses, like many previous international BIM surveys. Especially, finding BIM experts in the Middle East, South America, and Africa was challenging. Furthermore, some countries dominated respondents groups (89.7% from the U.S. in North America, 86.7% from Australia in Oceania, and

76.6% from South Korea in Asia). This may also mean that these countries had the greatest number of BIM users on each continent, but balanced sampling may be required in future surveys. The challenge with the number of responses may be overcome through an international collaborative survey with international organizations, such as buildingSMART.

A main contribution of this paper is that it attempted to establish a global survey framework on the status of BIM adoption and showed the global status of BIM adoption for the first time. When a more rigorous framework for a global BIM survey is created via further analysis, a long-term survey to track the worldwide status of BIM adoption can be conducted through an international collaborative survey.

ACKNOWLEDGMENT

This research was supported by a grant (13AUDP-C06781-01) from the Architecture & Urban Development Research Program funded by the Ministry of Land, Infrastructure and Transport of the Korean government

REFERENCES

[1] Berlo, L. V., Dijkmans, T., Hendriks, H., Spekkink, D., and Pel, W. (2012). "BIM QuickScan: benchmark of BIM performance in the Netherlands." *Proc., Proceedings of the CIB W78 2012: 29th International Conference.*

[2] Eadie, R., Browne, M., Odeyinky, H., McKeown, C., and McNiffb, S. (2013). "BIM implementation throughout the UK construction project lifecycle: An analysis." *Automation in Construction*, vol. 36, pp. 145-151.

[3] Kassem, M., Succar, B., and Dawood, N. (2013). "A proposed approach to comparing the BIM maturity of countries." *Proc., Poceedings of the CIB W78 2013: 30th International Conference* – Beijing, China, 9-12 October.

[4] Succar, B. (2009). "Building information modelling framework: A research and delivery foundation for industry stakeholders." Automation in Construction, vol. 18, issue. 3, pp. 357-375.

[5] Young, N. W., Jr., Jones, S. A., and Bernstein, H. M. (2007). "Interoperability in the Construction Industry." *SmartMarket Report*, McGraw Hill Construction, Bedford, MA, pp. 36.

[6] Jr., N. W. Y., Jones, S. A., Bernstein, H. M., and Gudgel, J. E. (2009). "The Business Value of BIM." *SmartMarket Report*, McGraw Hill Construction, Bedford, MA, pp. 52.

[7] Bernstein, H. M., Jones, S. A., Gudgel, J. E., Messina, F., Partyka, D., Lorenz, A., Buckley, B., Fitch, E., Laquidara, D., and Gilmore, D. (2010). "The Business Value of BIM in Europe." *SmartMarket Report*, McGraw Hill Construction, pp. 52.

[8] Lee. G., Lee, J., Jones, S. A., Uhm, M., Won, J., Ham, S., and Park, Y. (2012). "The Business Value of BIM in South Korea." *SmartMarket Report*, McGraw Hill Construction, Bedford, MA, pp. 60.

[9] Bernstein, H. M., Jones, S. A., Russo, M. A., Laquidara-Carr, D., Taylor, W., Ramos, J., Healy, M., Lorenz, A., Fujishima, H., Fitch, E., Buckley, B., and Gilmore, D. (2012). "Business Value of BIM in North America." *SmartMarket Report*, McGraw Hill Construction, Bedford, MA, pp. 64.

[10] Bernstein, H. M., Jones, S. A., Russo, M. A., Laquidara-Carr, D., Taylor, W., Ramos, J., Lorenz, A., and Terumasa, Y. (2013). "The Business Value of BIM for Construction in Major Global Markets." *SmartMarket Report*, McGraw Hill Construction, Bedford, MA, pp. 64.

[11] Bernstein, H. M., Jones, S. A., Russo, M. A., Laquidara-Carr, D., Taylor, W., Ramos, J., and Pineda, R. (2014). "The Business Value of BIM in Australia and New Zealand." *SmartMarket Report*, McGraw Hill Construction, pp. 64.

[12] Won, J., Lee, G., and Lee, C. (2009). "Comparative analysis of BIM adoption in Korean Construction Industry and Other countries." ICCEM, ICCPM 2009, Jeju.

[13] The National BIM Survey. (2011). "National BIM Report 2011" *NBS*, the National BIM Survey, pp. 21.

[14] The National BIM Survey. (2012). "National BIM Report 2012" *NBS*, the National BIM Survey, pp. 20.

[15] The National BIM Survey. (2013). "National BIM Report 2013" *NBS*, the National BIM Survey, pp. 28.

[16] The National BIM Survey. (2014). "National BIM Report 2014" *NBS*, the National BIM Survey, pp. 36.

[17] Sharif, T. (2011). "BIM in the Middle East." *Middle-East BIM report*, buildingSMART ME, pp. 64.

[18] Nikkie BP Consulting, Inc. (2011). "Japan 2011 BIM Survey", Nikkie BP Consulting, Inc., pp. 52.

[19] The National BIM Survey. (2013). "NBS International BIM Report 2013" *NBS*, the National BIM Survey. pp. 16.

[20] O'Leary, D. E. (2008). "Gartner's hype cycle and information system research issues." *International Journal of Accounting Information Systems*, vol. 9, issue. 4, pp. 240-252.

[21] Fenn, J., and Raskino, M. (2008). *Matering the HYPE CYCLE*, Harvard Business Review Press. pp.3-88

[22] Rogers, E. M. (2003). Diffusion of innovations, Free Press. pp.252-280

[23] Kreider, R., Messner, J., and Dubler, C. (2010). "Determining the Frequency and Benefit of Applying BIM for Different Purposes on Building Projects." *6th International Conference on Innovation in Architecture, Engineering and Construction (AEC)*, Penn State University, University Park, PA, USA.

[24] Messner, J., Anumba, C., Dubler, C., Goddman, S., Kasprzak, C., Kreider, R., Leicht, R., Saluja, C., and Zikic, N. (2010). "BIM Project Execution Planning Guide." The Computer Integrated Construction Research Program, pp. 134.

[25] Won, J., Lee, G., and Park, Y. (2010). "2010 Survey on BIM Adoption in Korea" *The BIM*, buildingSMART Korea.