Journal of Management and Sustainability; Vol. 5, No. 4; 2015
ISSN 1925-4725 E-ISSN 1925-4733
Published by Canadian Center of Science and Education

The Driving Force of Government in Promoting BIM Implementation

Shijing Liu[1], Benzheng Xie[1], Linda Tivendal[2] & Chunlu Liu[2]

[1] School of Management Engineering, Shandong Jianzhu University, Jinan, China

[2] School of Architecture and Built Environment, Deakin University, Geelong, Australia

Correspondence: Chunlu Liu, School of Architecture and Built Environment, Deakin University, Geelong, Australia. E-mail: chunlu.liu@deakin.edu.au

Received: August 15, 2015 Accepted: November 27, 2015 Online Published: November 30, 2015

doi:10.5539/jms.v5n4p157 URL: http://dx.doi.org/10.5539/jms.v5n4p157

Abstract

The adoption of Building Information Modelling (BIM) is one of the greatest technological innovations in the construction industry to date. However, the implementation of BIM lags far behind its potential due to the existence of various barriers. Strong government support is critical for the successful development and deployment of complex technology systems. BIM could seek government support to drive its implementation process and overcome the barriers. Through a survey, this paper aims to discover stakeholders' expectations of the government role in BIM implementation and explores specific ways for governments to promote BIM implementation. The research findings are expected to assist related departments to accelerate BIM implementation.

Keywords: Building Information Modelling, driving force, government

1. Introduction

Innovation is generally regarded as a major stimulant for national economic growth, especially in industrial and newly industrialised economies (Ernst & Kim, 2002; Jiancheng & Kaihua, 2012). Effective adoption of innovation plays an important role in the economic development of many countries under different social and economic systems (Guan et al., 2005). Building Information Modelling (BIM) is one of the greatest recent technological innovations in the building design and construction industry. It has also attracted the attention of the global architecture, engineering and construction (AEC) industry. BIM technology provides many direct and indirect benefits. It leads to labour market improvements, encourages more collaborative working practices and improves communication between project stakeholders (Allen Consulting Group, 2010). The adoption of a new technology in any industry poses challenges that need to be overcome (Furneaux et al., 2008). As a new technology in the construction industry, while BIM is expected to benefit the industry, a range of barriers have hampered its widespread implementation (Aibinu & Venkatesh, 2014). To overcome these barriers, governments can play a vital role as a driving force.

Government policies can potentially influence both the process and direction of innovation through their impact on industrial, consumer and public service demands (Herrera & Nieto, 2008). In terms of innovative processes, governments often play a critical role as providers of information and technology (Lemola, 2002). Some policies can be effective in promoting technological innovation while others may be ineffective or even have negative effects. National leadership and coordination are primarily driven by governments and this is the most critical factor in determining successful BIM implementation (Won et al., 2013; Smith, 2014). Strong government support is critical for successful development and deployment of complex technology systems (David & Steinmueller, 1994). Governments can promote the processes of development and deployment both directly and indirectly, and can play multiple roles, acting as project founder, financial sponsor, risk undertaker, interest moderator, collaboration facilitator and process monitor (Gao et al., 2014). Therefore BIM, as an emerging technology and a collaborative virtual information management system in the AEC industry, should seek the support of government to drive its implementation and take various measures to ensure it moves forward.

This paper concentrates on government functions and support in relation to the implementation of BIM, and investigates the degree and nature of public attention to the role of government as a driving force in BIM implementation. Also, this paper explores specific directions and measures that governments can pursue in order to promote BIM implementation. The findings of the research lead to proposed recommendations for

government to lead further BIM implementation.

2. Government Contributions to Promoting the Implementation of BIM

2.1 Government Functions in Promoting New Technology

Improvements in university–industry collaborative research and development (R&D) relationships and targeted technology development programs appear to have contributed to the improved performance of state and national economies (Feller, 1997). Additionally, governments as sponsors of technology have concentrated on funding basic research and private R&D (Von Tunzelmann & Acha, 2005). This indicates that the implementation of new technology involves both the industry and the education sector; therefore government functions in these fields are investigated.

Government is recognised as an important actor in relation to standardisation. Government can promote the development and diffusion of technology by conducting or investing in research, seeding the development of resources or services, forming state-led standard-setting consortia, establishing national science parks, procuring products and mediating private sector competition (Funk & Methe, 2001). The research on government intervention in technological innovation focuses mainly on technological innovation policies and intervention methods (Xiao & Ma, 2014). In terms of government intervention in the industry in relation to the adoption of new technologies, there are three relevant aspects: information support, financial support and personnel support (Moon & Bretschneider, 1997).

A successful national strategy for promoting domestic innovation often includes the active participation of a country's economic development board. Support in relation to taxation can include: low taxes, including tax holidays, an overall low tax rate or industry-specific low tax rates; and an R&D or intellectual property tax regime. Statistics show that many countries have added new tax vehicles to support modernisation and innovation. These tax incentives aim to change the risk/reward calculations of industry participants in order to encourage them to invest more in research, product development and business process improvements. These incentives are often supported by software (PricewaterhouseCoopers, 2010).

2.2 Government Contributions in Australia and China

The adoption of BIM concepts in the Australian construction industry can be traced back a decade or earlier. The use of BIM in the construction industry is not currently widespread and there have not been any government mandates to use BIM in projects of any note (Smith, 2014). However, in the past five years or so interest in BIM adoption has increased among many stakeholders in the AEC sector. Australian BIM practitioners are in the vanguard of global practice, engaging in ambitious demonstration projects of the highest complexity. They are also active in R&D, in terms of both basic research undertaken by universities and applied research driven by industry–research collaborations (CIBER, 2012).

Most of the national initiatives to drive the Australian construction industry towards BIM through the development of standards and protocols have been driven by the National Specification System of Australia (NATSPEC), BuildingSMART Australasia and the Australian Institute of Architects (AIA). The NATSPEC guidelines are flexible enough to accommodate use in different procurement contexts and can be viewed as one of the most comprehensive Australian BIM documents. Table 1 contains a summary of the strategies, standards and processes associated with BIM implementation that have been published by government and industry institutions in Australia.

Table 1. Summary of Australian document information

Date	Author/publisher	Title
Nov.2009	CRC for Construction Innovation	National Guidelines for Digital Modelling
Jun.2010	Digital Modelling and the Built Environment Working Group	Issues paper: Digital modelling and the built environment for Department of Innovation Industry, Science and Research
Oct.2010	Allen Consulting Group	Productivity in the building network: assessing the impacts of Building Information Models, report to the Built Environment Innovation and Industry Council
Dec.2010	AIA	BIM in Australia: A report on BIM and IPD forums
Jan.2012	ANZRS Committee	Australian and New Zealand Revit Standards (Version 3)
Jun.2012	buildingSMART Australasia	National Building Information Modelling Initiative Report
Aug.2012	Air Conditioning and Mechanical Contractors' Association (AMCA)	BIM–MEP Road Map 2012 Parliamentary Launch
Jan.2014	NATSPEC	BIM Education – Global Summary Report
Jun.2014	NATSPEC	BIM paper: Getting started with BIM

The Chinese AEC industry is in the early stages of BIM adoption. Contractors are adopting BIM at a faster rate than design professionals, while some barriers are inhibiting the use of BIM approaches, such as difficulties with changing traditional work process and legal issues (McGraw-Hill, 2014). With increasing development, the Chinese AEC industry is growing rapidly and becoming more sophisticated; hence there is an opportunity to drive improvement through the creation and adoption of national BIM standards. China now has a 2016 publishing goal for a national BIM standard and with robust education, training and implementation support, government efforts will help the Chinese industry to move forward (Ouellette, 2014). Table 2 presents a summary of information about the progress of BIM implementation in China.

Table 2. Summary of Chinese information

Date	Department/sector	Work content
Aug.2007	Ministry of Science and Technology	Establishing a key project, National Science and Technology Support Program and taking *Development of application software in the AEC industry based on BIM* as a key issue of the project
May.2011	Ministry of Housing and Urban Rural Development (MOHURD)	Releasing *2011~2015 Construction Information Development Program Outline* and determining to speed up the application of new technologies such as BIM in the AEC industry
Jan.2012	MOHURD	Releasing *Notice on the issuance of revised plan for construction standards*, including planning to organise the national standard *Uniform Standards of BIM Application* (NBIMS-CHN)
Mar.2012	China Academy of Building Research	Cooperating key enterprises of the AEC industry to set up a Chinese BIM industry technology innovation strategic alliance and undertaking organisation of national standards NBIMS-CHN approved by MOHURD
Oct.2013	Ministry of Science and Technology	Determining *China BIM industry technology innovation strategic alliance* to be one of the experimental alliances in the third group of the National Industrial Technology Innovation Strategic Alliances
Sep. 2014	MOHURD	Releasing *Advice on promoting the construction industry development and reform* and proposing to promote the application of BIM in the AEC industry
Feb. 2012 ~Jul.2014	Different provincial government departments	Various guidance and advice documents

The information summarised above illustrates how the process of BIM implementation is being promoted and driven by the Australian and Chinese governments. However, these governments' roles in driving BIM implementation are not yet as significant as in other countries such as the USA and the UK. The governments have the potential to promote BIM implementation in the industry, economic, and education and training sectors.

3. Research Design

Previous research has indicated that the response rate of a data survey increases when using short questionnaires (Edwards et al., 2002). In order to obtain an acceptable response rate for the survey, the questionnaire applied in this research consisted of three questions, presented in Table 3. Questions 1 and 2 aimed to investigate the

governments' driving force, while Question 3 was designed to discover critical directions for the governments to pursue. Question 3 allowed survey participants to select their top three choices, while the other two questions asked for a single choice.

Table 3. Questionnaire questions

1. What role should the government play in promoting BIM implementation? (tick single choice)
□ Leading role □ Guiding role □ General role □ Not involved
2. What role does the government play now in promoting BIM implementation? (tick single choice)
□ Leading role □ Guiding role □ General role □ Not involved
3. Which directions could be highlighted for the government promoting BIM implementation? (tick and rank top three choices)
□ Improve national standards (e.g. taking measures to follow the standards or sharing BIM data)
□ Drive BIM mandatory application (e.g. mandatory use in government procurement)
□ Fiscal and tax policies support (e.g. reducing software purchase cost)
□ Build a platform involved industry, university and research institution (e.g. funding tripartite cooperation)
□ Encourage BIM education and training (e.g. funding BIM professionals)
□ Establish university subjects (e.g. courses for software application, training seminar)

Group meetings were used to collect the survey data in this research. Survey sampling requires the selection of a small sub-population that is representative of the entire population. For this research, samples from four distinct populations associated with BIM implementation were selected: academic staff; university students; industrial BIM practitioners; and government officials related to AEC management disciplines. The questionnaires were sent to all respondents by email ahead of the group meetings, together with a plain language explanation of the research purpose.

A number of group meetings were held in China and Australia from the end of 2014 to early 2015. In total, 62 valid questionnaires were received. Among these, 25 respondents were from Australia and 37 were from China, including 14 respondents from industry, 10 government employees, 14 academic staff members and 24 undergraduate and postgraduate university students.

4. Investigation of Expected and Practical Government Roles

It was assumed that the respondents would have some expectations around the roles of government. The driving force of government was divided into 'leading role' and 'guiding role' in order to be investigated more accurately. The results of the survey are presented in Figure 1. Over 90% of respondents believed that government should play a very important role in the BIM implementation process, indicating that the respondents had expectations of government support. More than half of the respondents believed that government should play a leading role, take full advantage of its administrative functions and actively participate in the promotion process, while 37% of respondents believed that government should play a guiding role, which means not leading but inspiring the development of the industry.

The various types of respondents had different expectations of the government role. All 10 government employees, 12 out of 14 university academics, 11 out of 14 industry staff and 23 out of 24 students chose a leading role or a guiding role, and the selection of leading role was the most common among the groups. The results indicate the self-recognition of government staff of government actions, while the university sector is more dependent on government funding to support research and teaching. For industry employees, their expectations of government backing for BIM implementation were not as urgent as anticipated and depended more on their own economic conditions and employee skill levels.

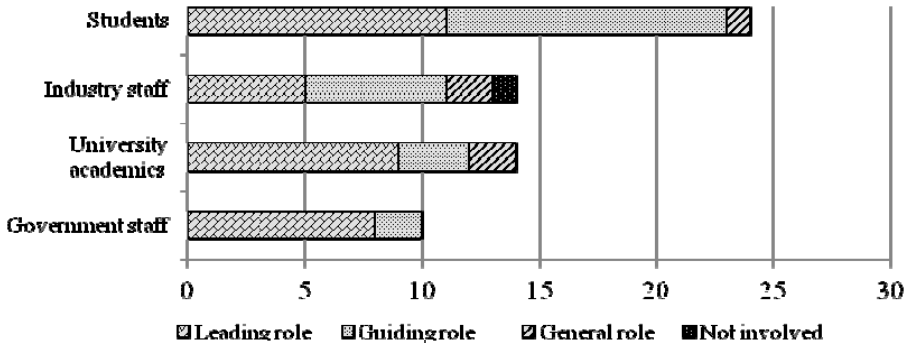

Figure 1. Expected roles of the governments

In terms of the current roles of the two governments, it can be seen in Figure 2 that almost half of the respondents believed that government was indeed playing a role to some extent in the process of BIM implementation, although only 7 out of 62 respondents held the opinion that government was playing a leading role. Almost half of the respondents noted that government was playing either a leading or guiding role which was consistent with the functions of government. However, the data does not support the expectation that government should play a leading role, at 53% (33 out of 62 respondents) or a guiding role, at 37% (23 out of 62 respondents). The data supporting leading or guiding roles for government was mainly contributed by government staff and university students, who accounted for 65% of the respondents.

From the perspective of the individual respondents, the AEC industry entities were the main participants in and beneficiaries of BIM implementation. However, only 4 out of 14 industry staff chose leading role or guiding role, almost 60% of these respondents considered that the governments were playing a general role, and 2 of the staff thought the governments were not involved, indicating that government support did not satisfy the expectations of the AEC industry. Significant issues were how to take necessary measures to support and encourage AEC industry entities to use BIM systems and how to reduce the cost of application through self-effort in the industry.

Although the government staff and the students mostly chose leading role or guiding role, with figures of 60% and 54%, this was not enough to affect the overall strength of the data, which also reflects that government support for university education and training was weaker than expected. The lack of research funding and expertise in relation to BIM practice has resulted in a small number of researchers of BIM application. Comprehensive evaluation of the governments' roles suggest that their current roles were far from meeting the expectations of the respondents, who wanted stronger support from government in promoting new technologies.

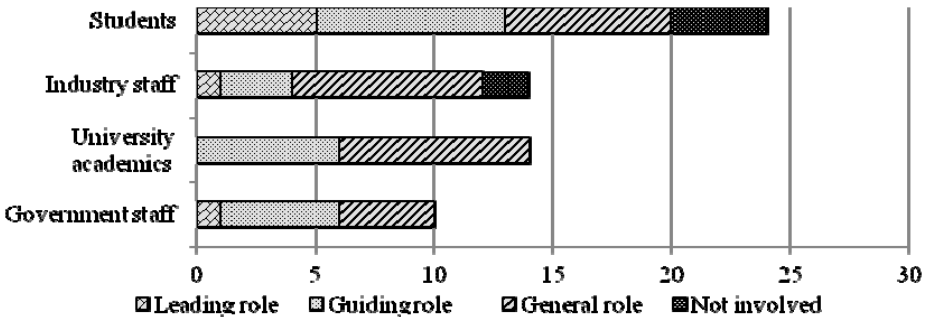

Figure 2. Current government roles

5. Driving Directions for Government in Promoting BIM Implementation

The top three choices of issues with high degrees of concern were 'Improve national standards', 'Encourage BIM education and training' and 'Drive mandatory BIM application', each of which covered around 60%, occupying 39, 36 and 35 out of the total number of respondents, followed by 'Build a tripartite cooperation platform' with a figure of 33, which is also over half. The results are presented in Table 4. The ranking of A/B/C

represents choice order 1/2/3 separately. It can be concluded that to pursue the main directions for BIM promotion, governments should pay attention to national BIM standards, and BIM education and training, and utilise opportunities for purchasing public facilities to promote BIM implementation. Special policies could strongly subsidise BIM education, foster the development of skilled professionals and utilise government fiscal policy to provide incentives for BIM implementation. Also, a significant and effective way to promote BIM implementation is by mandatory use in government procurement within the scope of government administration. Successful cases such as the Sydney Opera House in Australia (ACG, 2010) and the Shanghai World Expo Project in China (Liu & Zhang, 2014) provide excellent demonstrations of this in practice.

Table 4. Key directions for governments in BIM implementation

	Rank	Government staff	University academics	Industry staff	Students	Total∑
Improve national standards	A	7	3	2	8	20
	B	1	2	2	4	9
	C	0	3	3	4	10
Subtotal		8	8	7	16	39
Drive BIM mandatory application	A	2	5	1	4	12
	B	1	2	0	5	8
	C	4	2	3	6	15
Subtotal		7	9	4	15	35
Fiscal and tax policies support	A	1	0	5	1	7
	B	2	1	3	3	9
	C	2	2	4	5	13
Subtotal		5	3	12	9	29
Build a tripartite cooperation platform	A	0	4	2	4	10
	B	7	6	4	2	19
	C	0	2	1	1	4
Subtotal		7	12	7	7	33
Encourage BIM education and training	A	0	2	5	8	15
	B	0	2	4	5	11
	C	3	1	3	3	10
Subtotal		3	5	12	16	36
Establish university subjects	A	0	0	0	1	1
	B	0	0	0	6	6
	C	0	4	0	3	7
Subtotal		0	4	0	10	14

The top three choices of government staff were improving national standards (8 out of 10 respondents), driving mandatory BIM application (7 out of 10 respondents) and building a tripartite cooperation platform (7 out of 10 respondents), which can be explained because government staff tend to take advantage of governments' administrative measures to support BIM promotion and focus less on the problem of how to develop professional skills training. The emphasis of the government staff was on the development and management of the entire AEC industry and they considered that governments as clients who require the use of BIM could play a guiding role in the industry.

The university academics selected building a tripartite cooperation platform (12 out of 14 respondents), driving mandatory BIM application (9 out of 14 respondents) and improving national standards (8 out of 14 respondents) as their top three choices. They were more inclined towards building a platform for cooperation between universities, research institutions and industrial technology entities to promote BIM with the support of government funding. They mainly focused on theoretical research; hence they were hopeful of obtaining better teaching or research resources and practical opportunities from this platform. The authority and attributes of government simply meant governments are able to build this kind of platform with the necessary responsibilities and capabilities. No single party among the industry, universities or research institutions could achieve this alone.

The industry staff consistently selected the choices of government policy and economic support in education, while 80% of respondents chose 'Fiscal and tax policies support' and 'Encourage BIM education and training' as

the most important tasks. Both developed and developing countries have implemented taxation policies to encourage the development and application of new technology, which indicates that the measures taken by government that produce fiscal policies to support industry to carry out technological innovation and use new technology are highly effective. BIM funding for education and training to produce skilled personnel was the basis for BIM projects and equally important for the industry. Solving these problems not only overcame the BIM implementation cost, but also formed the foundation of future BIM implementation to achieve the maximum benefits of the new technology.

Half of the industry staff chose improving national standards and building a tripartite cooperation platform, which suggests companies also pay attention to BIM standardisation and external cooperation to ensure the sustainability of BIM implementation. On one hand, BIM technology requires a unified standard to regulate it and on the other hand, BIM technology undergoes continuous progress and change. In addition, the mandatory purchasing of public buildings and facilities was not strong enough to attract the attention of companies and this explains the little interest in 'Drive BIM mandatory application'.

The students concentrated their top three choices on 'Improve national standards', 'Encourage BIM education and training' and 'Drive mandatory BIM application', accounting for 16, 16 and 15 out of 24 respondents, over 60%, and the total trend of their choices is relatively close to those of other respondents, and so does not affect the overall evaluation of this part of the research.

The statistics for respondents' first single choice of the directions show some unanticipated results. It was unexpected for university academics to select 'Drive mandatory BIM application', but the highest first choice of government staff was 'Improve national standards', while industry staff chose 'Fiscal and tax policies support' and students preferred 'Improve national standards' and 'Encourage BIM education and training'. That is close to the results of previous research, indicating that as they have different roles in the process of BIM application, the respondents' views were also different, but this uncertainty did not have much impact on the trend of the general respondent samples.

6. Conclusions

The BIM concept and technology have been applied in practice worldwide and the great benefits of BIM application in the AEC industry are gradually being revealed. The driving force of government can support the industry and academic community in the implementation of BIM, as government legal and mandatory instructions can promote new technologies directly or indirectly. The BIM implementation process involves government staff, university academics, industry staff and university students. BIM technology connects these related participants. Under the guidance of government responsibility as the driving force, the promotion of BIM technology can be accelerated.

Despite a gap between the expected and practical government roles, the four groups of survey participants had a common expectation for the government role of introducing policies to promote BIM implementation. All the directions proposed for government support in the survey have a significant impact on the promotion of BIM implementation, among which the most significant were fiscal support, national standards and professional training. The public service resources that governments own make them capable of providing support for new technology innovation. It is recommended that by increasing the driving force of the government, the industry and academic community could be integrated as a whole. The positive effects of BIM include rapid development and achievement of industrialisation.

References

Aibinu, A., & Venkatesh, S. (2014). Status of BIM Adoption and the BIM Experience of Cost Consultants in Australia. *Journal of Professional Issues in Engineering Education and Practice, 140*(3). http://dx.doi.org/10.1061/(ASCE)EI.1943-5541.0000193

Allen Consuting Group. (2010). Productivity in the buildings network: assessing the impacts of Building Information Models, report to the Built Environment Innovation and Industry Council. Sydney.

Centre for Interdisciplinary Built Environment Research (CIBER). (2012). Building Information Modelling (BIM): Australian Perspectives and Adoption Trends. The University of Newcastle.

David, P. A., & Steinmueller, W. E. (1994). Economics of compatibility standards and competition in telecommunication networks. *Information Economics and Policy, 6*(3), 217-241. http://dx.doi.org/10.1016/0167-6245(94)90003-5

Edwards, P., Roberts, I., Clarke, M., DiGuiseppi, C., Pratap, S., Wentz, R., & Kwan, I. (2002). Increasing

response rates to postal questionnaires: systematic review. *BMJ, 324*, 1183. http://dx.doi.org/10.1136/bmj.324.7347.1183

Ernst, D., & Kim, L. (2002). Global production networks, knowledge diffusion, and local capability formation. *Research policy, 31*(8), 1417-1429. http://dx.doi.org/10.1016/S0048-7333(02)00072-0

Feller, I. (1997). Federal and state government roles in science and technology. *Economic Development Quarterly, 11*(4), 283-295. http://dx.doi.org/10.1177/089124249701100401

Funk, J. L., & Methe, D. T. (2001). Market-and committee-based mechanisms in the creation and diffusion of global industry standards: the case of mobile communication. *Research Policy, 30*(4), 589-610. http://dx.doi.org/10.1016/S0048-7333(00)00095-0

Furneaux, C. W., Vassilev, N., Burgess, J., Brown, K., & Ward, M. (2008). *Streamlining local government: evaluating an eGovernment initiative in South East Queensland*.

Gao, P., Yu, J., & Lyytinen, K. (2014). Government in standardization in the catching-up context: Case of China's mobile system. *Telecommunications Policy, 38*(2), 200-209. http://dx.doi.org/10.1016/j.telpol.2013.10.002

Guan, J. C., Yam, R. C., & Mok, C. K. (2005). Collaboration between industry and research institutes/universities on industrial innovation in Beijing, China. *Technology Analysis & Strategic Management, 17*(3), 339-353. http://dx.doi.org/10.1080/09537320500211466

Herrera, L., & Nieto, M. (2008). The national innovation policy effect according to firm location. *Technovation, 28*(8), 540-550. http://dx.doi.org/10.1016/j.technovation.2008.02.009

Jiancheng, G., & Kaihua, C. (2012). Modeling the relative efficiency of national innovation systems. *Research Policy, 41*(1), 102-115. http://dx.doi.org/10.1016/j.respol.2011.07.001

Lemola, T. (2002). Convergence of national science and technology policies: the case of Finland. *Research policy, 31*(8), 1481-1490. http://dx.doi.org/10.1016/S0048-7333(02)00077-X

Liu, H., & Zhang, L. (2014). Lessons Learned from Case Projects and Enterprises Where BIM Was Utilized. *Proceedings of the 17th International Symposium on Advancement of Construction Management and Real Estate.* Springer, 961-968. http://dx.doi.org/10.1007/978-3-642-35548-6_99

McGraw-Hill. (2014). The Business Value of BIM for Construction in Major Global Markets: How contractors around the world are driving innovations with Building Information Modelling. *Smart MarketReport.* United States.

Moon, M. J., & Bretschneider, S. (1997). Can state government actions affect innovation and its diffusion?: An extended communication model and empirical test. *Technological Forecasting and Social Change, 54*(1), 57-77. http://dx.doi.org/10.1016/S0040-1625(96)00121-7

Ouellette, J. (2014). *Promoting National BIM Standards in China*. Retrieved from http://bit.ly/1XAGdaM

PricewaterhouseCoopers. (2010). Government's Many Roles in Fostering Innovation. Retrieved from http://pwc.to/1RoAW0S

Smith, P. (2014). BIM Implementation – Global Strategies. *Procedia Engineering, 85*, 482-492. http://dx.doi.org/10.1016/j.proeng.2014.10.575

Von Tunzelmann, N., & Acha, V. (2005). Innovation in 'low-tech'industries. *The Oxford handbook of innovation,* 407-432.

Won, J., Lee, G., Dossick, C., & Messner, J. (2013). Where to focus for successful adoption of building information modeling within organization. *Journal of Construction Engineering and Management, 139*(11). http://dx.doi.org/10.1061/(ASCE)CO.1943-7862.0000731

Xiao, L., & Ma, X. (2014). The Influence of Government Intervention on Logistics Enterprise's Adoption of Information Technology. *Journal of Digital Information Management, 12*(1), 8-17.

Copyrights

Copyright for this article is retained by the author(s), with first publication rights granted to the journal.

This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (http://creativecommons.org/licenses/by/3.0/).