Economic, Social and Environmental Sustainability: The Role of Technology and Political Dialogue
18–20 May 2023
Valetta, Malta & Online
make learn TIIM PIConf
Management, Knowledge and Learning
International Conference
Technology, Innovation and Industrial Management
Sustainable Development

Factors Affecting the Use of Building Information Modelling within the Context of Work from Home

Kongkiti Phusavat
Kasetsart University, Thailand
fengkkp@ku.ac.th

Pacharapong Chunoon
Kasetsart University, Thailand
pacharapong.chunoon@hotmail.com

Bordin Rassameethes
Kasetsart University, Thailand
fbusbdr@ku.ac.th

Sasivimol Meamphon
Kasetsart University, Thailand
fbusssm@ku.ac.th

Suparerk Sooksmarn
Kasetsart University, Thailand
fbussrs@ku.ac.th

Abstract

Remote work (especially Work-from-home or WFH) has been adapted due to the COVID-19 containment. The impacts on the Architecture Engineering and Construction (AEC) industry need to be assessed due to the rapid integration of the Building Information Modelling (BIM) into Thailand's construction industry for short- and long-term benefits. The purposes of this study are to identify and prioritize the factors which relate to an employee's intention to embrace and adapt BIM when dealing with WFH. A total of 62 BIM users who undertook WFH were surveyed. The Unified Technology Acceptance and Usage of Technology or UTAUT model was adapted for this analysis, together with a Structural Equation Modelling or SEM. The findings revealed that Performance Expectancy and Facilitating Conditions are the significant factors contributing to the use of BIM. In addition, based on the moderator's analysis, the intensity of WFH affects a user's intention to use BIM.

Keywords: Organizational behavior, management, Work-from-home, technology adaptation

INTRODUCTION

Due to the need to contain the COVID-19 pandemic, many countries require private firms to undertake Work-from-home (WFH) when continuing their business operations. The AEC industry, which is traditionally dependent on face-to-face discussion and interactions, needs to adjust to this regulatory requirement. Some of the impacts include the ability to manage supply chains for a construction project and to work with customers on a project's requirements (Al-Mhdawi *et al*., 2021). Disruptions due to delivery delays and higher cost of construction materials are common in a construction project during the pandemic. In addition, construction project management has experienced many challenges such as reliance on international labour, safety and health, quality assurance with subcontractors, etc.

Even before the implementation of WFH (to contain the COVID-19 pandemic), Building Information Modelling or BIM has been integrated into construction project planning and management. BIM's goal is to improve the communication of construction-related information (Hussain *et al*., 2018). In the past, designs and construction plans are shared among various specialists through digital technology and traditional mediums like paperwork and documents. BIM advocates the database-first approach to help share the collaboration among various stakeholders. The reason is that BIM establishes a standard storage for information regarding design, requirements, and construction of a project (Eadie *et al*., 2014). Such information helps reduce misunderstanding, miscommunication, and mistake through the life-cycle phases of a construction project. BIM can contain 3D models and 2D drawings.

PROBLEM BACKGROUND

From early 2020 until 2022, Thailand had imposed restriction on labour mobility, requirement of social distancing, confinement of construction sites, and control of building materials' supply chains. In other words, WFH became common for office operations, including construction projects (e.g., design, development, verification, contract management, construction, inspection, etc.). Due to the rush (for a compliance with the COVID-19 containment), the willingness to adapt and implement BIM has been one of the essential issues among the firms within the AEC industry. Despite some positive effects from WFH such as schedule flexibility, it can also contribute to a sense of uncertainty (e.g., stress and anxiety) and could lead to some hesitation to embrace BIM (Pamidimukkala and Kermanshachi 2021). The reason is that BIM has been widely used when working in an office with face-to-face interactions.

WFH implies the need to be vigilant about data security and protection as well as confidentiality of client-colleague discussions (Didin *et al*., 2021).

RESEARCH QUESTIONS AND OEBJECTIVES

What are the challenges facing a firm which needs to adapt remote work (especially WFH) while implementing the BIM for its business operations is essential to help avoid work disruptions (e.g., miscommunication, mistakes, and delays)? The Unified Technology Acceptance and Usage of Technology or UTAUT model is to be applied when developing a survey. The benefits from this insight will include better planning and preparation for a firm when using BIM during remote work (especially WFH). Not only it is expected to help minimize work disruption, but productivity of the employees should also be improved due to the knowledge on these challenges.

IMPORTANT LITERATURES

There are several issues relating to the study. They include WFH, BIM, and UTAUT. They can be summarized as follows.

WFH (within the context of Remote Work)

Working remotely (especially WFH) appear to be part of a longer-term solution to deal with the uncertainty derived from the pandemic, cost management, and changing nature of a workforce. Managing cost more effectively and efficiently through less usage of office space is stressed throughout the COVID-19 pandemic. The nature of a workforce today has rapidly changed over the past decade. Flexible workspace and locations are increasingly expected by recently- graduated employees. Despite the positive impacts, it is important that the challenges need to be recognized (PricewaterhouseCoopers, 2022). They include the following- (1) the need to adapt to a new way of working- upgrade of technology (e.g., cloud- based tools), (2) the necessity of creating a new working and communication culture- flexibility and shift from control to facilitating work and learning, (3) the assurance on data safety and security, and (4) the recognition of non-verbal clues from employees to maintain management and administration.

Specially, for the employees, the primary challenges from remote work which affect their productivity are trust, communication, willingness to adapt to new technology for work, etc. Feeling of uncertainty, loneliness and isolation are commonly cited as a major roadblock for effective remote work. Higher mistakes, more work disruptions, and lower productivity are the impacts from these negative feelings (Aczel *et al*., 2021, and Ipsen *et al*., 2021). Within the context of the AEC industry, people often feel less secure when there is a lack of active engagement and face-to-face discussion (Pamidimukkala and

Kermanshachi 2021). On the other hand, Quezon (2021) described tools and equipment when using WFH to manage a construction project.

BIM

BIM was developed in the 1980s for the AEC industry. BIM aims to strengthen the management of information and documentation throughout the lifecycle of a construction project. Despite a slow integration of BIM in Thailand (estimated to be about 20% of large Thai construction firms), the Association of Siamese Architects under Royal Patronage strongly supports the use of BIM in Thailand. BIM provides many benefits to construction firms due to better cost and document controls (Czmoch and Pekala 2014).

BIM's utilization in a construction firm has not been without a challenge. The resistance to adapt to BIM due to the unfamiliarity of data standard and the willingness to embrace digital technology as a backbone of construction project management are commonly cited. This is due to the level of digital proficiency, lack of engagement and supervisory, and feeling of unease when making a mistake contribute to the challenges of BIM's implementation (Venkatesh 2000; and Panuwatwanich and Peansupap, 2013).

UTAUT

According to Venkatesh *et al*., (2003), UTAUT helps highlight the behavior of and intention for the use of digital technology. UTAUT is based on many conceptual frameworks that relate to human behavior and psychology. They are Technology Acceptance Model or TAM, Innovation Diffusion Theory, Theory of Reasoned Action, Motivation Model, Theory of Planned Behavior, and Social Cognitive Theory. It is important to point out the following. UTAUT is like TAM. The primary difference is that UTAUT has integrated two external factors, namely social and equipment availability. See Figure 1 and Table 1.

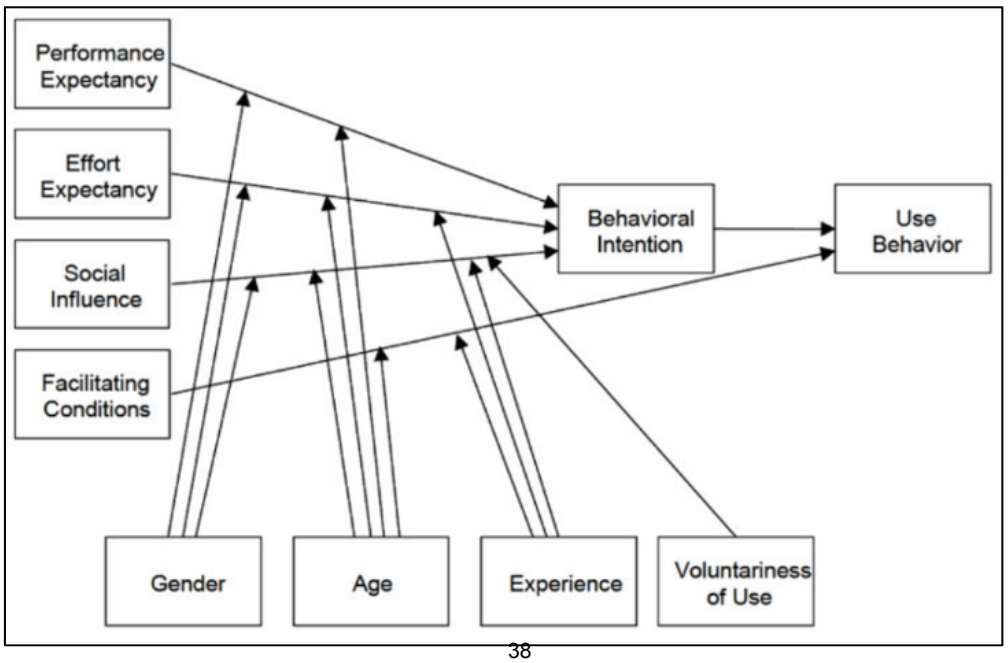

Figure 1: Illustration of UTAUT
Source: Venkatesh et al., (2003)

Table 1: Key Components within UTAUT

Factors	Implications
Performance Expectancy *The degree to which the user expects that using a system will help him or her to attain gains or achievement at work.*	The users believe that using a system will enhance their performance.
	Motivation is significant when a person expects to receive what they want as a reward for completing a task, such as more money or a promotion.
	The system's capabilities will improve the employee's work performance.
	The perception that a system can result in higher achievement at work than previously.
Effort Expectancy *The degree of ease associated with the use of a system.*	The users believe a system is simple and can be easily operated.
	The perception that a system is not too difficult to comprehend and learn
Social Influence *The feeling expressed by an individual that it is important for him or her to adapt to or use a new system due to the perception of others (e.g., use of a new software indicates higher work quality).*	The recognition that a person's expression can influence how another person adapts to a new system.
	The recognition that adapting to or using a new system can enhance or strengthen an image and/or a social position within an organization.
Facilitating Conditions *The degree to which an individual believes that there is organizational and technical infrastructure to support the use of a system.*	The need to have confidence that support is available to ensure an ability to operate a system effectively.
	The support of digital infrastructure and accessories by an organization to enhance ease of system usage.
	Working facility that meets the requirements or experiences of a person who needs to adapt to or use a system.

Method

The study is considered as survey research. Within the context of WFH, current BIM users in the AEC industry would be selected. Google Forms was created for a survey which would be disseminated to 24 AEC firms (known as BIM users). The data was collected during the second quarter of 2022. This indicates that the survey participants have had some WFH experiences since the guideline and recommended restriction were announced in early 2020. To categorize raw data and create model for analysis, Statistical Package for the Social Sciences (SPSS) and Analysis of Moment Structures (AMOS) 21.1 were used.

The survey has a total of 15 questions and is divided into two parts. They are: (1) a respondent's demographics with the focus on age, BIM experiences, and WFH level, and (2) a list of 12 questions

with the use of a five-point Likert scale- strongly agree for 5 while strongly disagree for 1. It is important to note that the second part is derived from UTAUT model which was proposed by (Venkatesh *et al*., 2003) after also some discussion with former BIM users during the development of a research model. See Table 2.

Table 2: Illustration of a Survey

Factors		Questionnaire Items
Performance Expectancy	PE1	During WFH, BIM has been useful and beneficial to my work.
	PE2	During WFH, BIM has improved quality and productivity of my work.
Effort Expectancy	EE1	During WFH, BIM has been relatively easy to use.
	EE2	During WFH, learning to operate BIM has been simple and quick.
Social Influence	SI1	During WFH, my project supervisor and colleagues appear to be supportive when using BIM.
	SI2	During WFH, my company has encouraged and supported the use of BIM
Facilitating Conditions	FC1	During WFH, I have enough resource to work with BIM (e.g., computer/ notebook, internet speed, SIM card).
	FC2	During WFH, there is strong compatibility between my computer/notebook and BIM.
Computer Anxiety	ANX1	I'm hesitant to use BIM for my WFH since I'm afraid of making mistakes that I cannot personally solve.
	ANX2	I feel discouraged and uncertain about using BIM away from office work.
Behavioural Intention	BI1	I feel confident that I would continue to use BIM in the future.
	BI2	Despite a possibility to use less WFH, I continue to use BIM with ease and comfort.

Simply put, the research model consists of the following factors: (1) Performance Expectancy or PE, (2) Effort Expectancy or EE, (3) Social Influence or SI, (4) Facilitating Conditions or FC, and (5) Computer Anxiety or ANX. The study determines whether these factors have a direct impact on behavioral intention to use BIM during WFH (BI). In addition, the research model includes the moderator which can provide good insights the predictive power of the model and increase or decrease relationship between dependent and independent variables in the model. Venkatesh et al. (2003) suggested four moderators which are: (1) Gender, (2) Age, (3) Experience, and (4) Voluntariness of use. It is important to point out that, the gender was removed since, during the development of the research model, it was suggested that this moderator would not play a significant role within in the context of WFH.

There are five hypotheses in the study. They are as follows. Also See Figure 2.

- H1. Performance Expectancy (PE) has a significant positive influence on Behavioral Intention to use BIM during WFH.
- H2. Effort Expectancy has a significant positive influence on Behavioral Intention to use BIM during WFH.

- H3. Social Influence has a significant positive influence on Behavioral Intention to use BIM during WFH.
- H4. Facilitating Conditions has a significant positive influence on Behavioral Intention to use BIM during WFH.
- H5. Computer Anxiety has a significant negative influence on Behavioral Intention to use BIM during WFH.

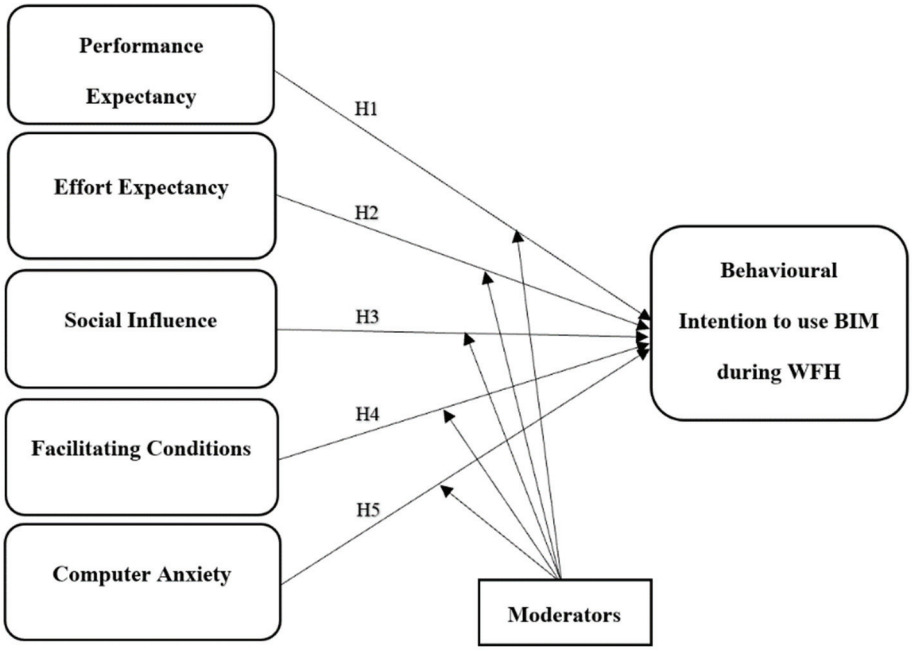

Figure 2: Research Model

Results

There are a total of 62 participants who completed the survey entirely. To assure that the size is acceptable, the rule of 10-times was used. The ten-times rule is the most widely used to evaluate small sample sizes suggested by (Hair *et al*., 2021). The rule illustrates that the minimum sample size must be greater than 10 times the number of latent variables pointing to the dependent variable. Therefore, the sample size (N=62) exceeds the ten-time rule since there are five independent variables pointing to one dependent variable (10 x 5 = 50 minimum samples). The details of the survey participants are as follows. See Table 3. Also, see Table 4 for their responses which generally indicate strong agreement with a statement (except for the Computer Anxiety subject).

Table 3: Details of Survey Participants

Characteristic (for Moderators)	Criteria	Frequency	Percentage
Age	20-25	8	13%
	26-30	**24**	39%
	31-35	16	26%
	36-40	3	5%

	41-45	6	10%
	46-50	3	5%
	51 or above	2	3%
BIM Experience	0-1year	20	32%
	2-3 years	**22**	35%
	4-5 years	10	16%
	6-7 years	2	3%
	Above 7 years	8	13%
Level of WFH	1-2 days per week	13	21%
	3-4 days per week	10	16%
	>4 days per week	**39**	63%

Table 4: Illustration of Descriptive Statistics

Factors	**Description**	**Mean**	**STD**
PE1	During WFH, BIM has been useful and beneficial to my work.	3.87	1.109
PE2	During WFH, BIM has improved quality and productivity of my work.	3.82	1.124
EE1	During WFH, BIM has been relatively easy to use.	3.34	1.200
EE2	During WFH, learning to operate BIM has been simple and quick.	2.98	1.235
SI1	During WFH, my manager or colleagues are helpful during the use of BIM.	3.58	1.153
SI2	During WFH, my company has encouraged and supported the use of BIM.	4.08	0.874
FC1	During WFH, I have enough resource to work with BIM (e.g., computer/ notebook, internet speed, SIM card).	3.73	1.176
FC2	During WFH, there is strong compatibility between my computer/notebook and BIM.	3.65	1.118
ANX1	I'm hesitant to use BIM for my WFH since I'm afraid of making mistakes that I cannot personally solve.	2.65	1.368
ANX2	I feel discouraged and uncertain about using BIM away from office work.	2.34	1.330
BI1	I feel confident that I would continue to use BIM in the future.	4.39	0.817
BI2	Despite a possibility to use less WFH, I continue to use BIM with ease and comfort.	4.47	0.762

Confirmatory Factor Analysis or CFA is applied to analyze the relationship between the factors and to help verify the SEM model. See Figure 3. Also see Table 5 which underlines the suitability of the model for further analysis. Composite Reliability (CR), Average Variances Extracted (AVE) and Factor Loadings methods are used to assess the acceptability of the model. It is important to note that it is acceptable when CR > 0.7 and AVE > 0.5 (as suggested by Bacon *et al*., 1995). Cronbach's alpha is utilized to evaluate the internal consistency of the Likert-based survey items.

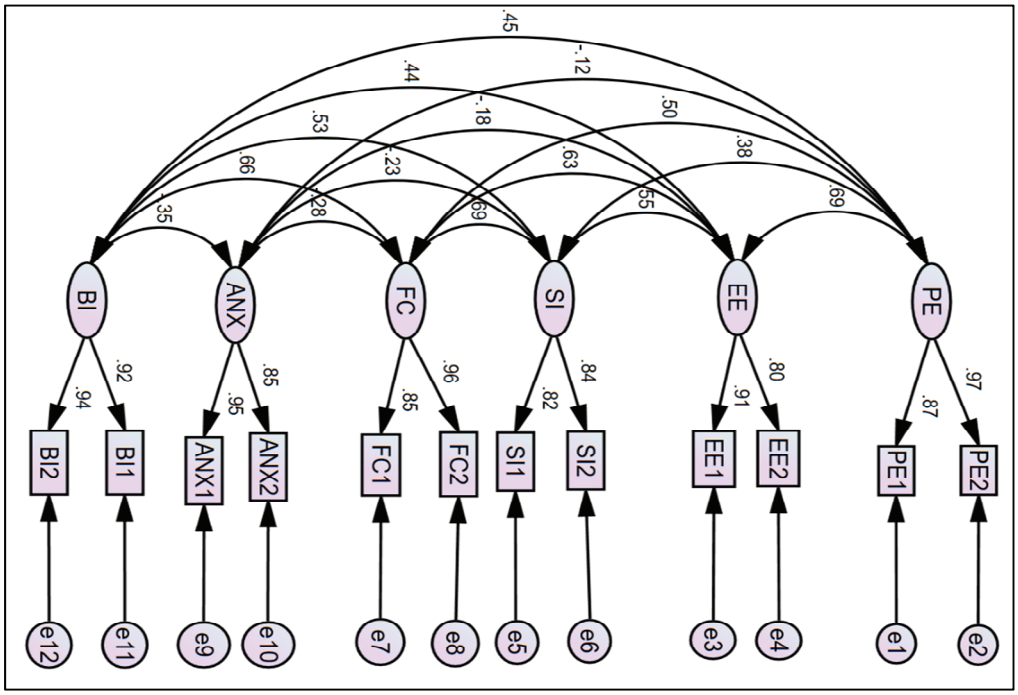

Figure 3: Results from the CFA

Table 5: Summary of the Model's Reliability and Suitability for Use

Construct	Item	Loadings	Cronbach's alpha	Overall Cronbach's alpha	CR (>=0.7)	AVE (>=0.5)
PE	PE1	0.866	0.871	0.772	0.92	0.85
	PE2	0.970				
EE	EE1	0.912	0.816		0.81	0.74
	EE2	0.801				
SI	SI1	0.820	0.722		0.83	0.69
	SI2	0.837				
FC	FC1	0.855	0.863		0.87	0.82
	FC2	0.958				
ANX	ANX1	0.951	0.864		0.88	0.81
	ANX2	0.848				
BI	BI1	0.921	0.925		0.96	0.87
	BI2	0.941				

Afterwards, the SEM is developed which resembles UTAUT. This development also helps evaluate the proposed hypotheses. It appears that PE and FC contribute significantly (and positively) to BIM usage during WFH. See Figure 4 and Table 6.

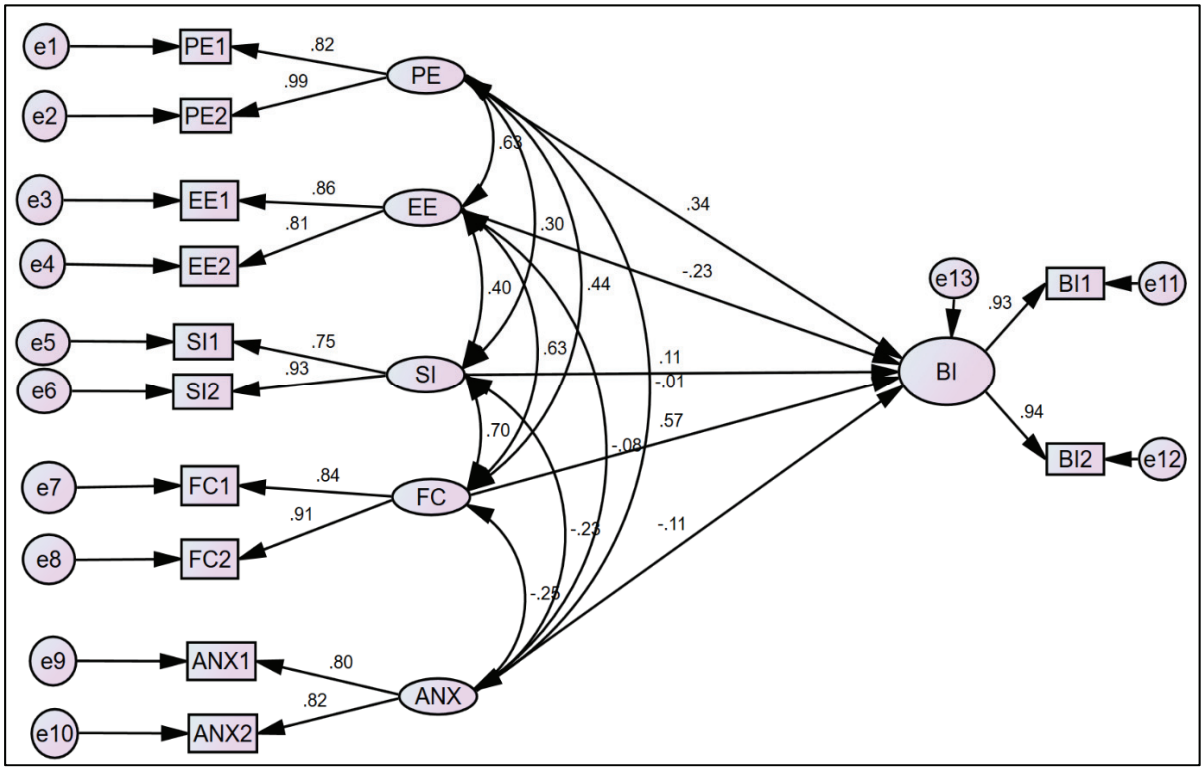

Figure 4: Illustration of SEM

Table 6: Results of Hypothesis Testing

Hypothesis	Path Coefficient (β)	P Value	Decision
(1) PE → BI	0.336	0.019	Acceptance
(2) EE → BI	-0.226	0.232	Rejection
(3) SI → BI	0.114	0.495	Rejection
(4) FC → BI	0.570	0.009	Acceptance
(5) ANX → BI	-0.106	0.365	Rejection

The next step is to integrate the three primary moderators into the determination of the factors affecting BIM usage during WFH. Age is categorized into seven groups (in reference to Table 3). The one-way ANOVA is applied to test the impact from the age group. The result show that there is no difference among the age groups toward behavioural intention to use BIM during WFH due to P-value > 0.05 (which is not significant). The experience in using BIM in this research is divided into five levels (in reference to Table 3). The results reveal that there is no significant effect from the BIM experience in BIM towards the intention to use BIM during WFH (P-value > 0.05). See Tables 7 and 8.

Table 8: ANOVA Results from the Age as the Moderator

		Sum of Squares	df	Mean Square	F	P-Value
BI1	Between Groups	7.251	6	1.209	1.987	.083
	Within Groups	33.458	55	.608		
	Total	40.710	61			
BI2	Between Groups	5.498	6	.916	1.683	.142
	Within Groups	29.938	55	.544		
	Total	35.435	61			

Table 9: ANOVA Results from the BIM Experiences as the Moderator

		Sum of Squares	df	Mean Square	F	P-value
BI1	Between Groups	6.012	4	1.503	2.469	.055
	Within Groups	34.698	57	.609		
	Total	40.710	61			
BI2	Between Groups	4.110	4	1.028	1.870	.128
	Within Groups	31.325	57	.550		
	Total	35.435	61			

Interestingly, the level of WFH, as the moderator, shows a significant impact on the intention to use BIM during WFH (mainly the BI1 component) with P-value less than 0.05. See Table 10.

Table 10: ANOVA Results from the Level of WFH as the Moderator

		Sum of Squares	df	Mean Square	F	P-value
BI1	Between Groups	4.097	2	2.048	3.301	**.044**
	Within Groups	36.613	59	.621		
	Total	40.710	61			
BI2	Between Groups	3.169	2	1.584	2.897	.063
	Within Groups	32.267	59	.547		
	Total	35.435	61			

A further examination underlines the significant difference between the level 1-2 days per week and more than 4 days per week for WFH. The significant value or P-value is 0.014. The mean difference of both levels is negative (-0.641). This highlights that an employee with the highest level of WFH (i.e., more than 4 days per week) is willing and shows the intention to use BIM during WFH.

Table 11. Multiple comparisons using LSD

Dependent Variable	WFH Level, designated as (I)	WFH Level, designated as (J)	Mean Difference (I-J)	Std. Error	Sig.
BI1	1-2 days per week	3-4 days per week	-.377	.331	.260
		More than 4 days per week	**-.641***	.252	**.014**
	3-4 days per week	1-2 days per week	.377	.331	.260
		More than 4 days per week	-.264	.279	.348
	More than 4 days per week	1-2 days per week	.641*	.252	.014
		3-4 days per week	.264	.279	.348

Based on the above findings, there are three factors that affect the intention to use BIM during WFH. They are PE, FC, and the level of WFH. See Figure 5.

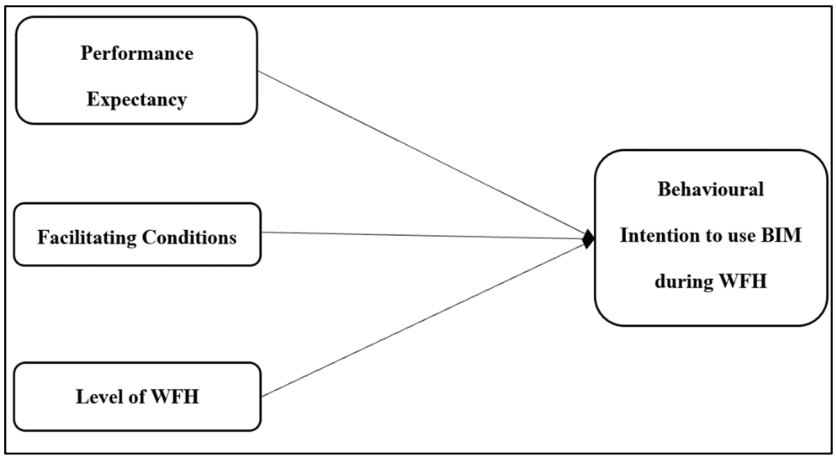

Figure 5: Illustration of the Research Findings

Discussion and Conclusion

The results from the survey highlight the following for the AEC industry (which has promoted the integration of BIM into business planning and operations). AEC employees are more willing to embrace and use BIM during WFH when receiving organizational supports on hardware (computer, laptop, internet, SIM card) with comparable software for operations. AEC employees generally perceive the benefits of BIM use (even when they have to undertake WFH) in terms of better project deliver and quality with higher work productivity when comparing with a traditional practice. However, construction firms need to pay the attention to anxiety due to perceived insufficient support when an employee is faced with technical and non-technical problems such as communication. Finally, a typical employee with a high level of WFH shows more willingness to use BIM.

REFERENCES

Aczel, B., Kovacs, M., Van Der Lippe, T., & Szaszi, B. (2021). Researchers working from home: Benefits and challenges. *PloS one*, *16*(3), e0249127.

Al-Mhdawi, M. K. S., Brito, M. P., Abdul Nabi, M., El-Adaway, I. H., & Onggo, B. S. (2022). Capturing the impact of COVID-19 on construction projects in developing countries: A case study of Iraq. *Journal of Management in Engineering*, *38*(1).

Bacon, D. R., Sauer, P. L., & Young, M. (1995). Composite reliability in structural equations modelling. *Educational and psychological measurement*, *55*(3), 394-406.

Czmoch, I., & Pękala, A. (2014). Traditional design versus BIM based design. *Procedia Engineering*, *91*, 210-215.

Didin, F. S., Maharani, B. P., & Mardiono, I. (2021). Work from home study: mental workload, gender, and calorie needs. *Jurnal Sistem dan Manajemen Industri*, *5*(1), 1-7.

Eadie, R., Odeyinka, H., Browne, M., Mahon, C., & Yohanis, M. (2014). Building information modelling adoption: an analysis of the barriers of implementation. *Journal of Engineering and Architecture*, *2*(1), 77-101.

Hair Jr, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2021). A primer on partial least squares structural equation modelling (PLS-SEM). Sage publications.

Hussain, A. M. A., Othman, A. A., Gabr, H. S., & Aziz, T. A. (2018, December). Causes and impacts of poor communication in the construction industry. In *2nd International conference: sustainable construction and project management-sustainable infrastructure and transportation for future cities, Egypt* (pp. 16-18).

Ipsen, C., van Veldhoven, M., Kirchner, K., & Hansen, J. P. (2021). Six key advantages and disadvantages of working from home in Europe during COVID-19. *International Journal of Environmental Research and Public Health*, *18*(4), 1826.

Pamidimukkala, A., & Kermanshachi, S. (2021). Impact of Covid-19 on field and office workforce in construction industry. *Project Leadership and Society*, *2*, 100018.

Panuwatwanich, K., & Peansupap, V. (2013, July). Factors affecting the current diffusion of BIM: a qualitative study of online professional network. In *Creative Construction Conference, Budapest, Hungary* (pp. 6-9).

PwC (PricewaterhouseCoopers) 2022. "Asia Pacific Workforce Hopes and Fears Survey 2022", accessed as of Oct. 3, 2022: https://www.pwc.com/gx/en/asia-pacific/hope-and-fears/asia-pacific-hopes-and-fears-survey-2022-v2.pdf

Quezon, E. T. (2021). Effect of covid-19 pandemic in construction labor productivity: a quantitative and qualitative data analysis.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS quarterly*, 425-478.