Understanding the Relation between BIM Application Behavior and Sustainable Construction: A Case Study in China

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Abstract: Building information modeling (BIM) is based on 3D models for collaborative management of information, which leads the innovative development of information transformation in the construction industry. In recent years, sustainable construction has become a hot topic in construction research. With the concept of sustainable development, this type of construction advocates for the sustainable optimization of construction models and processes. A person’s good behavior can bring enormous potential, which is critical for the promotion of new technology in new areas. Nowadays, the integration of BIM technology and sustainable construction has increasingly attracted attention in the industry of construction. But many issues and gaps still exist when using them. The aim of this study is to investigate the intrinsic relationship between BIM application and sustainable construction from the perspective of user application behavior, and to reveal the key influential factors of BIM application behavior in order to improve the application efficiency of BIM in sustainable construction. Specifically, the present study builds a theoretical model by integrating the theory of planned behavior and BIM application. Based on a questionnaire survey of 353 BIM users, we conducted an empirical analysis using the structural equation model method. The results showed that the perceived usefulness and ease of use of BIM technology are the key influential factors in behavior attitude. BIM behavior intention, actual behavior, and behavior attitude have a positive effect on sustainable construction. Ultimately, practical support is provided for the effective integration of BIM with sustainable construction in China.

Keywords: BIM; sustainable construction; application behavior; structural equation

1. Introduction

Globally, the wide-ranging and in-depth application of information technology has been considered as an important strategic tool for improving production and management efficiency in the construction industry [1]. With creative technical systems and management method, building information modeling (BIM) is regarded as a modern information technology that can solve issues in the construction process. BIM definitions vary [2], but the Associated General Contractors of America defines the term as “a systemic information data exchange platform, in which the data user’s demand can be drawn and analyzed to form new information. By applying BIM technology, users can make precise decisions and promote the process of construction” [3]. Similarly, as an innovative digital tool, BIM is widely applied in the life cycle of a project for visualization, scheduling, communication, and teamwork among project construction, as well as to promote the process of forming, accumulating, controlling, transforming, and delivering construction data in an effective manner [4]. BIM can generate a computer-based
three-dimensional model to visualize the whole life-cycle process of construction involving the phase of planning, design, construction, and operation [5].

Since 2000, BIM has received much attention in academia and the construction industry due to its potential and ability to achieve performance improvements and high-quality construction and has been gradually applied in massive construction projects around the world [6]. As international organizations and governments gradually take action to apply BIM in the whole life-cycle process of construction, the needs of BIM have increased [7]. BIM technology is acknowledged as a building modeling tool that can implement data integration, object-oriented parametric analysis, and building model management [5]. Most countries have published related BIM development strategies and implementation documents as technical standards [8]. Various types of data can be loaded onto a three-dimensional model and enables it to fit the demands of users [9]. However, BIM is a key tool for users to achieve their objectives through the efficient application of BIM methodology. Many challenges have to be addressed, such as identifying important data for retrofitting, integration and efficient transformation of monitored information, and identification of uncertainty [10]. In newly designed buildings, BIM technology can simulate the entire construction process through the use of a BIM software system [11], while 2D-drawing software only shows the architecture of a building project and is useful for the design stage rather than the entire life-cycle process [12].

In the last several decades, the influence of construction buildings on the environment has been widely debated [13,14]. The link between environmental issues and the construction industry has been acknowledged by the academic and construction sectors [15–17]. In view of growing sustainability problems, such as decreasing carbon dioxide emission and application dependency on non-renewable energy sources, a number of building projects have been driven to adopt green and sustainable construction strategies, which have been gradually recognized as a useful way to prompt the development of the construction industry [18,19]. Depending on advanced technology and effective construction process, BIM has been considered as an opportunity that can bring substantial benefits to the architecture, engineering, and construction (AEC) industry [20]. Thus, due to the function of collaboration, BIM is also considered as a valuable approach to develop sustainability systems and can expand the application of sustainable construction [21]. In addition, BIM can offer large amounts of resources in the process of sustainable construction for projects stakeholders [22]. Furthermore, BIM can develop and transform data on energy consumption and offer effective work-flow data in the phase of project operation [23]. In particular, BIM can provide an information-sharing framework that generates association among stakeholders through the life cycle of sustainable construction, thereby creating an environment that is conductive to input, output, and transform data in the BIM system [24].

In recent years, remarkable improvement has been achieved in the AEC industry in China. Many grand buildings have been constructed. However, users have experienced difficulty and wasted time in managing massive construction projects. At the same time, energy consumption and environmental pollution are two factors to be considered by government and construction practitioners as it can block the progress of advanced technology. To deal with these problems, the assimilation of BIM technology and sustainable construction is moderately being developed in China. For instance, Shanghai Center, a well-known large construction project, has saved approximately 40% in energy expenses and built a management system under the integration of BIM usage and sustainable construction. Thus, a good approach is to push forward the integration of BIM technology and sustainable construction, which will prompt the advancement of construction and achieve environmental goals in China.

Behavior is the expression of the individual’s use of task. During the construction process, the user’s good performance will improve the completion of the entire construction process. Organizational behavior theory posts that a person’s behavior is affected by the reciprocity between an organization and the environment. Investigating the regularity of people’s psychological and behavioral willingness in a specific organization could promote the power of managers to understand and influence personal behavior, thereby efficiently fulfilling the organization’s predetermined goals. In the application process of BIM technology, effective BIM usage behavior plays a critical role in the construction
process. It can promote a user’s work efficiency and make BIM application smoother in the whole life-cycle process. Systematic literature found that existing studies mainly focus on BIM technology development, lifecycle management applications, and the impact of sustainable construction combined with controversial issues. However, few studies have explored the perspective of individual behavior, considering the user’s intention and actual behavioral differences to explore the effect of BIM application on sustainable construction. Thus, we conducted a questionnaire survey on the behavior of BIM technology applications with planned behavior theory and structural equation model verification analysis, and eventually identified the relation between BIM behavior and sustainable construction.

The structure of this research is shown as follows. Section 1 shows the current background of BIM application and the benefit of sustainable construction to the AEC industry, and illustrates the objective of this study. Section 2 presents the research literature review, which indicates the existing benefits of BIM technology application and sustainable practices in construction projects. Section 3 shows the study theories and hypotheses. Section 4 defines the research methodology. Section 5 analyses the research data. Section 6 makes a decision about the research findings. Section 7 recommends strategies for the development of the integration of BIM application and sustainable construction and provides a guide for future research directions. Section 8 shows research limitations and prospects.

2. Literature Review

2.1. BIM Application

At present, to guarantee the completion of high-quality construction projects, participants are striving for the effective functionality of current building projects. Thus, many new building projects are applying the BIM technology methodology [25,26]. Arguments on the BIM application mainly focus on collaboration across organizational boundaries and technology application. Some researchers have argued that BIM technologies provide a platform to initiate a data shift in construction [27,28]. However, others hold that effective applications of BIM need a technological update to adapt to the complex working process of construction projects [23,29,30]. With case studies in 28 typical construction projects, Mehran (2016) showed that most of the construction projects applying BIM technologies did not consider the application of the entire life cycle but only focused on one application area of a construction project, especially in the phase of designing [31]. Similarly, Martin (2018) showed that complex BIM solutions are possible to be initially used in limited areas. Therefore, visualization and clash research have been regarded as the foundation of successful collaboration [23]. Zheng (2018) proposed a new approach based on stakeholder value network (SVN) to simulate and visualize value exchanges among primary stakeholders when applying BIM technology. Finally, the study offered a visualized tool to measure the perceived value of BIM stakeholders and to improve the “buy-in” decisions by stakeholders [32]. Meanwhile, Martain (2018) provided a proof-of-concept for an integrated assessment of building construction applying BIM. The overall effects on the building’s total impact are calculated for the various options to identify design specific hot-spots. Different aspects of the results can be visualized to support intuitive design guidance [33].

Scholars have conducted related research from the perspective of technological application. Most of these studies aim to examine and enhance the integration of BIM technology application across project networks [34]. For example, Doan (2019) conducted a few studies focusing on investigating the opinions of relevant participants in New Zealand for the application of green building and its relation and effective collaboration with BIM technology. The research provided several suggestions to improve green building development under the integration of BIM [35]. Wang (2019) focused on the point of combining BIM application and GIS in sustainable construction and discussed practical BIM applications in projects. The results showed that an integrated system should be optimized technically to prompt the integration of BIM application in the AEC industry [36].
2.2. BIM in Sustainable Construction

At present, sustainable construction faces many challenges globally, including the incompetence of complete life-cycle data arrangement and conducting data analysis to share with project participants [37]. BIM can store and manage building project data on energy consumption and offer detailed work-flow data during construction operation [38]. Thus, users can easily upload, extract, check, or transform information by using the BIM platform [39]. Through visual characteristics, BIM technology can ease these restrictions and achieve energy-saving goals [40]. Therefore, it is important for users to ensure the active application of BIM technology in sustainable buildings, thus improving sustainable development around the world.

Providing potentially large benefits in integrating BIM technology and sustainable construction, several authors have conducted several analyses of construction projects, integrating BIM with sustainability assessment approaches [41–43]. In the last two decades, numerous academic studies on the integration of BIM and sustainable construction have been published. Some scholars have conducted reviews. For example, Timothy (2018) investigated the profound barriers faced by construction stakeholders in their attempts to integrate BIM and sustainability practices in the construction processes. The three key barriers are industry’s resistance to change from traditional working practices, an extended period of adapting to innovative technologies, and the lack of understanding of the processes and work flows required for BIM and sustainability [44]. Gao (2019) wrote a review on the combination of BIM technology and the building energy model, which was applied in the phase of energy-saving building designs [39]. Based on a simulation analysis with BIM technology in sustainable construction, Kota (2014) focused on using BIM technology with a day-lighting simulation in sustainable construction and analyzed performance [45]. With regard to building life cycle, Wong (2015) provided a review of BIM application in sustainable construction [46]. Lu (2017) reviewed the application of BIM throughout the life cycle of a building project for sustainable construction [47]. With regard to the economy, Curry (2013) concentrated on evaluation in the life-cycle process and managed the integration of BIM and life-cycle assessment [48]. This method can streamline data transformation for a project and offer feedback to both tools. From the perspective of sustainable design, Antwi (2017) investigated awareness with actual applications of BIM technology in sustainable construction and found that the BIM application can save the construction cost and improve the working efficiency [49].

2.3. BIM Application Behavior

Organizational behavior holds that the individual’s psychological intention can improve managers’ behavior guidance and result in prediction, thereby promoting the effective realization of the organization’s goal. The strength and weakness of the behavior have an active effect on enhancing the effectiveness of behavior exercise. From this point of view, as an emerging technology, the application behavior in BIM directly affects the technical characteristics of the contribution to project revenue.

Many scholars focus on the use of individual point of view, particularly the individual psychological identity, on the use of BIM technology. From the technical adoption level, based on BIM technology adoption and BIM technology application benefits, Walasek (2017) conducted research and analysis through the Polish construction practitioners’ survey to find the key factors that affect BIM technology adoption and summarize the solutions [50]. In China, Zheng (2016) proposed a new model by improving the UTAUT (Unified Theory of Acceptance and Use of Technology) model and examined the influencing factors of BIM technology adoption, analyzed the questionnaire, and concluded that perceived usefulness and task technology matching are the main influencing factors for the adoption of BIM technology [51]. Donya (2016) conducted research from the perspective of BIM technology adoption risk, which invited United Arab Emirates (UAE) construction practitioners to perform a BIM technology application behavior survey and effective analysis of the data [33]. The effect of the UAE BIM technology application on the main risk factors was observed and relevant improvement recommendations were proposed [49]. BIM application satisfaction refers to the use of individual...
psychological acceptance of BIM technology and can be used to predict the effect of BIM usage behavior on the construction industry. Rodgers (2015) related BIM application projects in Australia through questionnaire collection and semi-structured talks. The results showed that BIM satisfaction is one of the nine important factors of BIM application, and using BIM technology plays a key role in promoting it [49].

3. Research Theory and Hypothesis

3.1. Research Theory

The theory of planned behavior (TPB) is a method that takes the theory of expected value as a starting point and interprets individual behavior preference and decision-making process after handling data [52]. According to the TPB, the behavior intention of a person is derived from three factors: behavioral attitude, subjective norms, and perceptual behavior control [53]. All three determinants are based on a potential belief structure: the belief in behavior, norms, and controls. The belief in behavior provides negative attitudes to behavior, and normative beliefs can also bring social pressure or subjective norms. Control beliefs will affect the formation of effective behavior.

In particular, when planned behavior theory is applied to technical products, the theoretical compatibility and potential complements strengthen the explanatory power of TPB by combining two variables in the technology acceptance model (TAM): perceived usefulness and perceived ease of use [54]. For BIM technology users, perceived usefulness mainly refers to the efficiency and convenience of applications brought about by the BIM technology. TAM holds that when an individual considers a new product, it is usually compared with the existing product, which compares the BIM technology with the usefulness and ease of use of traditional building information technology, considering the advantages and disadvantages of both [55]. According to the theory of attitude expectation value, behavioral attitude refers to the evaluation of the individual’s affection for the execution of BIM technology, which includes the belief attitude and result evaluation of the two parts, corresponding to the perceived usefulness and perceived ease of use variables in the TAM [56].

Therefore, in the light of the technical attributes of BIM technology itself, this paper preserves the original variables and increases the perceived usefulness and the perceived ease of use as the reasonable variables for behavioral attitudes to maintain the model’s good interpretation ability, and finally, to measure the impact of the actual behavior of BIM technology on sustainable construction and development. The final subtext variable is sustainable construction, and the improved concept model is shown in Figure 1.

![Figure 1. Framework for the assessment model.](image-url)
3.2. Research Assumptions

3.2.1. Relationship among Behavior Attitude, Subjective Norm, and Behavior Intention

This paper takes perceived usefulness and perceived ease of usefulness as the pre-factor variables to explain behavior attitude, representing the efficiency and convenience measurement of BIM technology. Behavior intention usually refers to an individual’s intention to perform an established action, which is considered as a prerequisite for immediate conduct [57]. It is mostly the degree of individual recognition for conducting and is the premise of the exercise of the action. Subjective norms refer to the external environmental pressures that individual actors need to consider when proceeding with the project. In using BIM technology, subjective norms mainly include construction project technical implementation rules, BIM technology application satisfaction, government-related promotion policies, and social recognition. Behavior intention is mostly the degree of individual recognition for conducting and is the premise of the exercise of the act. The binding force of subjective norms can effectively control the strength and weakness of behavior intention [57]. For example, the government’s policy promotion of BIM technology will offset the sense of change of resistance of BIM users and increase the intention to act. Subjective norms play a critical role in the formation of individual behavioral attitudes. For example, the introduction of new policies by the relevant legislative departments of the government standardizes the behavior of users and guides them to form correct behaviors. Behavior attitudes are individuals’ pre-assessments and behavioral tendencies based on their own values. Positive behavior attitudes lead to behavior intention [56]. Compared with traditional CAD (Computer Aided Design) software application in the process of construction, the subjective specification pressure has a greater influence in the BIM technology application. For example, BIM technology is a new technology that will have a remarkable impact on the application of the cognitive deficiencies, investors for the application of BIM technology, application of interests, and subjective norms on BIM technology users.

Based on the aforementioned considerations, the following assumptions are proposed:

**H1.** Behavioral attitudes have a significant positive effect on behavior intention.

**H2.** Subjective norms have a significant positive effect on behavior intention.

3.2.2. Relationship of Perceptual Behavior Control with Behavior Intention and Actual Behavior

Perceived behavioral control is the result of controlling beliefs and perception, which can be defined as an individuals’ belief in the existence of certain elements that may promote or hinder the performance of certain behaviors (such as time, money, and opportunity). Normally, the perceptual behavior control used by BIM technology should include perceived ease of use and perceived usefulness, but growing evidence shows that users can develop a controlling degree by selecting objects, considering that in project construction employees are subject to express their emotional attachment about traditional construction software. What makes sense is that the tendency of psychological ownership will influence people’s choice of BIM technology.

Ultimately, the study used the issue of product ownership as one of the observation variables of perceptual behavior control. Organizational behavior holds that individual behavior depends on the result of behavior intention and behavior control. Therefore, the perceptual behavior control and behavior of BIM technology determine the actual behavior of the users. The actual behavior mainly refers to the frequency and proficiency of BIM technology. Importantly, users and the external control factors are unified; thus, the actual behavior can be performed.

Based on the preceding considerations, the following assumptions are proposed:

**H3.** Perceptual behavior control has a significant positive effect on the behavior intention.

**H4.** Perceptual behavior control has a significant positive effect on actual behavior.

**H5.** Behavior intention has a significant positive effect on actual behavior.
3.2.3. Relationship between Behavior Intention, Behavioral Attitude, Actual Behavior, and Sustainable Construction

The World Commission on Environment and Development defines sustainable development as the ability to meet current needs without compromising the needs of future generations [58]. Similarly, the effect of BIM technology usage on sustainable construction can only be measured from the community by interpreting the views of the masses. Therefore, this paper measures the impact of sustainable construction from BIM technology, including improving the efficiency of construction and operation, as well as reducing pollution, resource consumption, and other low carbon behaviors. A growing number of studies have shown that promoting and using new technology must consider the influence of actual behavior [59]; thus, the effective application of actual BIM behavior will be profitable for sustainable construction. Behavior intention represents the individual’s degree of application intention. If the user has a stronger intention to apply BIM technology in an actual sustainable construction project, then this condition will prompt the efficiency of operation.

Based on the aforementioned considerations, this study presents the following assumptions:

**H6.** Actual behavior has significant positive effects on sustainable construction.

**H7.** Behavior intention has a significant positive impact on sustainable construction.

**H8.** Behavior attitude has a significant positive effect on sustainable construction.

4. Research Design

4.1. Questionnaire Design

This study involved a total of seven potential variables. The main potential variables are perceived usefulness, perceived ease of use, subjective norms, perception behavior control, behavior intention, actual behavior, and sustainable construction. The variables in this questionnaire were measured by using a five-point Likert scale scoring method in which 1 is “very consistent” and 5 indicates “total non-conformity or objection.” To guarantee the questionnaire validity, first of all, we invited 10 experts in engineering management to perform pre-test questionnaires. With the expert feedback on the individual question settings, we conducted a few adjustments of text description and eventually formed a formal questionnaire. The questionnaire is shown in Table 1.
Table 1. Research variable of private sectors’ behaviors and relating source indices.

| Research Variable | Reliability Test | Validity | AVE | Source |
|-------------------|------------------|----------|-----|--------|
| **BIM Behavior Intention** | | | | |
| 1. I will insist on using BIM technology. | 0.843 | GFI = 0.987 | REMA = 0.076 | TLI = 0.965 | [43] |
| 2. I think BIM technology application has a significant effect on the life cycle of the project. | | | | |
| 3. I think BIM technology can bring many benefits. | | | | |
| **Perceived Ease of Use** | | | | |
| 1. BIM application allows me to achieve the desired results. | 0.886 | GFI = 0.911 | REMA = 0.077 | TLI = 0.978 | [44] |
| 2. I can easily master BIM technology. | | | | |
| 3. I think the BIM application is very simple. | | | | |
| 4. BIM technology can bring benefits to the project within a shorter period. | | | | |
| **Perceived Usefulness** | | | | |
| 1. The use of BIM technology has increased my work efficiency. | 0.912 | GFI = 0.911 | REMA = 0.063 | TLI = 0.997 | [43] |
| 2. BIM technology application promotes the quality of my work. | | | | |
| 3. I think the BIM application is very helpful for my work. | | | | |
| 4. I think using BIM technology makes the entire project more intuitive. | | | | |
| 5. I think BIM technology can make project construction more systematic. | | | | |
| **Perceptual Behavior Control** | | | | |
| 1. I will consider its application cost. | 0.954 | GFI = 0.957 | REMA = 0.072 | TLI = 0.986 | [45] |
| 2. I will worry about its data safety. | | | | |
| 3. I will consider its benefit for a project. | | | | |
| 4. I will consider its feasibility. | | | | |
| **Actual Behavior** | | | | |
| 1. I am very confident in fully mastering BIM technology. | 0.968 | GFI = 0.957 | REMA = 0.072 | TLI = 0.986 | [44] |
| 2. I am skilled in using BIM technology. | | | | |
| 3. Many colleagues are using BIM technology. | | | | |
| **Behavioral Attitude** | | | | |
| 1. Using BIM technology is a good idea. | 0.898 | GFI = 0.911 | REMA = 0.077 | TLI = 0.978 | [45] |
| 2. I enjoy using BIM technology. | | | | |
| 3. The process of using BIM technology makes me happy. | | | | |
| 4. I am willing to use BIM technology for daily work. | | | | |
| **Subjective Norm** | | | | |
| 1. I am very satisfied with the application of BIM technology in actual projects. | 0.854 | GFI = 0.911 | REMA = 0.077 | TLI = 0.978 | [45] |
| 2. BIM technology application recognition is high. | | | | |
| 3. BIM technology is being promoted by the government. | | | | |
| 4. I think the BIM technology application specification is mature. | | | | |
| 5. I understand the concept of BIM technology very clearly. | | | | |
| 6. I am very clear about the application of BIM technology. | | | | |
| **Sustainable Construction** | | | | |
| 1. Stronger BIM behavior intention can improve the development of sustainable construction. | 0.836 | GFI = 0.932 | REMA = 0.073 | TLI = 0.965 | [43] |
| 2. Positive BIM behavior attitude can prompt the completion of sustainable construction. | | | | |
| 3. Actual BIM behavior can effectively control the cost of a construction project. | | | | |

4.2. Data Collection

Questionnaire surveys were made by hand-sending (128), delivering emails (129), and posting via Questionnaire Star, a well-known mobile application in China (96). Table 2 offers a profile of the respondents. The selection principles of the research object are based on the following two points:
firstly, China’s BIM technology marketing and development speed is fast, but the technology market is mainly concentrated in big cities, particularly Beijing and Shanghai. Therefore, the city in which the respondent is located is the key factor that ensures the representativeness of the data. Considering that different users have various habits and behavioral psychology, the questionnaire was conducted in a random sample. To ensure that the questionnaire is filled out to reflect the current behavior of BIM technology and understanding of construction practitioners on the concept of sustainable construction, the potential research objects of this paper are from construction practitioners related to the use of BIM technology in cities such as Shanghai, Beijing, Nanchang, Jinan, Dalian, Chongqing, Qingdao, Dezhou, Shenzhen, and Guangzhou, which cover different ages. The majority of occupational and income group respondents have experience in using BIM technology. A total of 353 samples were collected from the survey, with a detailed sample description as shown in Table 2. After SPSS analysis, 6 questionnaire answers were found to have faults, 34 questionnaires selected the same option, and the final recovery of 313 were valid questionnaires. Thus, effective recovery rate is 88.7%, and sample size meets the requirements of model analysis.

| Table 2. Distribution of respondents. |
|--------------------------------------|
| **Category** | **Frequency** | **Percentage** |
| Gender | | |
| Male | 231 | 65% |
| Female | 122 | 35% |
| Education | | |
| Specialists and below | 34 | 10% |
| Bachelor | 57 | 16% |
| Master | 134 | 38% |
| PhD | 128 | 36% |
| Age | | |
| 20–30 | 78 | 22% |
| 31–40 | 90 | 25% |
| 41–50 | 125 | 35% |
| Above 50 | 58 | 18% |
| Position | | |
| Top manager | 39 | 11% |
| Designer | 46 | 13% |
| Project manager | 70 | 20% |
| University professor | 26 | 7% |
| BIM engineer | 118 | 33% |
| Government official | 54 | 16% |
| Parties | | |
| University | 26 | 7% |
| Developer | 69 | 20% |
| Construction enterprise | 136 | 38% |
| Consultancy institute | 68 | 19% |
| Government department | 54 | 16% |
| BIM experience | | |
| 0–5 years | 126 | 36% |
| 5–10 years | 100 | 28% |
| Above 10 years | 127 | 36% |

5. Data Analysis

5.1. Reliance Analysis

Credibility is the degree of consistency in measuring the same object by different test methods. At present, the academic community generally uses Cronbach’s alpha coefficient for the signability test. If the alpha coefficient approaches 1, then the items we select are closer to the corresponding variable. A Cronbach’s alpha coefficient shows effective reliability between 0.6 and 0.8, while it is closer to 0.8, indicating the most effective reliability. In this study, research formed a reliability coefficient value of 0.914, which indicates a higher reliability degree.
5.2. Validity Analysis

The validity test is mainly divided into convergence validity and a content validity test, which is generally used to extract the AVE (average variance extracted) value of the average variance for convergence validity test, and the factor load after orthogonal rotation is used in the content validity test. The article uses AMOS 20 to calculate the AVE value, and the average extraction variance for each submersible variable is greater than 0.5 such that the convergence effect of the questionnaire is better. Most factor loads are greater than 0.5 after orthogonal rotation and the indicators of the factor load is 0.508 to 0.866, which means that the statistics were significant, indicating that the questionnaire had better content validity. The preceding values are detailed in Table 1.

5.3. Model Quality Inspection

5.3.1. External Quality Inspection of Model

Firstly, we used Amos 20 to fit the model, and the model fit shows that most of the indicator values are close to the fit standard value, indicating that the overall model fits the basic standard, but the goodness fit index (GFI) was 0.893 < 0.9, adjusted post-fitness index (AGFI) was 0.812 < 0.9, comparative fitting index (CFI) was 0.856 < 0.9, and non-standard adaptation index (NFI) value was 0.817 < 0.9, which indicate that the model has not reached the desired level and need to be debugged and corrected. Charles (1994) pointed out that the fitting indices of modeling cannot easily satisfy fitting standards during the first attempt. Due to data deviation or problems with the conceptual model it is difficult for most models to meet all the fit criteria [60]. It is inevitable that there existed errors when we measured the indexes, and we must delete these irrational indexes and restart the model until the ideal results are achieved. Multiple experimental studies on the structural equation model have found that the deviation of the collected data or problems of the conceptual model itself cause difficulty for most models to meet all the fit criteria at once. According to the assumptions of the planned behavior theory and the fit model provided by Amos when the model was first fitted, the indicator corrects the model appropriately until the adaptability indicators are at the ideal level and can be analyzed. After the modified model, the fitness index (GFI) is 0.91 > 0.9, adjusted post-fitness index (AGFI) is 0.958 > 0.9, value added adaptation index (RFI) is 0.965 > 0.9, and non-standard adaptation index (NFI) value is 0.977 > 0.9. The fitness test results before and after the model correction are shown in Table 3. The differences between the original model and the modified model are clear to understand in Table 3, based on the model matching criteria. Finally, considering the BIM behavioral intention and sustainable construction, we obtained the non-standardized path coefficient as shown in Figure 2.

| Goodness of Fit Index | Original Model | Modified Model | Model Matching Criteria |
|-----------------------|----------------|----------------|------------------------|
| GFI                   | 0.893          | 0.91           | GFI > 0.9              |
| CFI                   | 0.856          | 0.965          | RFI > 0.9              |
| AGFI                  | 0.812          | 0.958          | AGFI > 0.9             |
| RMSEA                 | 0.05           | 0.05           | RMSEA < 0.08           |
| RMR                   | 0.036          | 0.036          | RMR < 0.05             |
| NFI                   | 0.817          | 0.977          | CFI > 0.9              |
| TLI                   | 0.877          | 0.932          | TLI > 0.9              |
| PNFI                  | 0.489          | 0.512          | PNFI > 0.5             |
| P-value               | 0.026          | 0.026          | P < 0.05               |
| X2/df                 | 1.341          | 1.213          | X2/df < 2              |
5.3.2. Intrinsic Quality Inspection of Model

The CR is used to test the degree of internal consistency between the observed variables of the submersible variables. Richard uses a lower standard guideline and believes that CR is above 0.6, indicating that the combined confidence of potential variables is good. To perform this, the study used the following formula:

$$\rho_c = \frac{(\sum \lambda)^2}{(\sum \lambda)^2 + \sum \theta}$$

The combined signability value of each variable is greater than 0.60, indicating that the model has a good intrinsic quality, where $\rho_c$ is the combination of confidence. The value $\lambda$ represents the standardized coefficient of the observed variable on the submersible variable, and $\theta$ is the amount of error variation of the indicator variable.

5.4. Model Empirical Analysis

5.4.1. Regulation Effect Analysis

First of all, we performed descriptive statistics and data center processing for the indicator of the submersible variable with SPSS (Statistical Product and Service Solutions, International Business Machines Corporation, Armonk, NY, USA) 20.0 and analyzed the Pearson correlation of the adjustment variable, which eventually resulted in the data as shown in Table 4. Among the four adjustment variables, the individual concept is significantly related to all the potential variables in the planned behavior model, and the most obvious influencing variables are behavior intention and actual behavior.
### Table 4. Model goodness-of-fit index.

| Assumed Path                        | Estimates | T-Value | S.E  | P    | Test Results |
|-------------------------------------|-----------|---------|------|------|--------------|
| Behavior intention → Sustainable construction | 1.83      | 8.765   | 0.059 | ***  | Important significance |
| Behavior intention → Actual behavior | 0.12      | 7.543   | 0.049 | ***  | Important significance |
| Subjective norm → Behavior intention | 0.57      | 5.543   | 0.043 | ***  | Important significance |
| Behavior attitude → Sustainable construction | 0.82(0.76) | 3.125   | 0.028 | **   | Important significance |
| Behavior attitude → Behavior intention | 0.25      | 7.793   | 0.049 | ***  | Important significance |
| Perceptual behavior control → Actual behavior | 0.23(0.34) | 5.543   | 0.043 | ***  | Important significance |
| Perceptual behavior control → Behavior intention | 0.1       | 2.335   | 0.028 | **   | Important significance |
| Actual behavior → Sustainable construction | 0.76(0.71) | 3.55    | 0.056 | ***  | Important significance |

Note: The numbers in parentheses in Table 4 indicate assumption road non-normalized coefficient value after the rejection of the mediation variable “behavior intention.”; * denotes 0.05 significance level, ** indicates 0.01 significance level, and *** represents 0.001 significance level.

#### 5.4.2. Model Validation Analysis

The revised model path coefficients and research hypothesis test results of the aforementioned structural equations are shown in Table 4. As the slope represented by the non-standardized path coefficient is more statistically significant, this study adopts the non-standardized path coefficient value. Hypothesis validation is based on empirical results on BIM technology behavior and measurements of the impact on sustainable construction. On the one hand, Table 4 shows that behavioral attitudes have a significant positive effect on behavioral intention ($\beta = 0.25$, $T$ value = 7.793, and $p < 0.001$); thus, H1 assumption is effectively validated. Subjective norm has a significant positive effect on behavior intention ($\beta = 0.57$, $T$ value = 5.543, $p = 0.01$); thus, H2 assumption is validated. Perceptual behavior control has a significant positive effect on behavior intention ($\beta = 0.1$, $T$ value = 2.335, $p < 0.01$); thus, H3 assumption is effectively verified. Perceptual behavior control has a significant positive effect on actual behavior ($\beta = 0.23$, $T$ value = 5.543, $p < 0.05$); thus, H4 assumption is effectively verified. Behavior intention has a significant positive effect on actual behavior ($\beta = 0.12$, $T$ value = 7.543, $p < 0.001$); thus, H5 assumption is validated. Actual behavior has a significant positive effect on sustainable construction ($\beta = 0.76$, $T$ value = 3.55, $p < 0.001$); thus, H6 assumption is validated. Behavior attitude has a positive significant effect on sustainable construction ($\beta = 0.82$, $T$ value = 3.125, $p < 0.001$); thus, H7 assumption is validated. Behavior intention has a positive effect on sustainable construction ($\beta = 1.83$, $T$ value = 8.765, $p < 0.001$); thus, H8 assumption is validated.

To further explore the influence of the application behavior of BIM technology users, this study attempts to eliminate the intermediary variable by comparing the result of introducing the intermediary variable “behavior intention” with no introducing. The specific path coefficient change is shown in Table 4. When the intermediary variable “behavior intention” is removed, the effect change between the remaining variables is not obvious except that the direct effect of subjective norms on the actual behavior is improved. Behavioral intention has a certain intermediary effect on the path subjective norm and actual behavior, and when the model introduces the intermediary variable “behavior intention”, the effect of subjective norm on the actual behavior will be reduced, and its indirect effect is obviously lower than the direct effect.

#### 6. Discussion

Analysis of the aforementioned structural equation model path shows that the three variables, namely, BIM technology behavior attitude, actual behavior, and behavior attitude, affect sustainable construction. In particular, behavior intention has a significant active influence on the application
of BIM technology in sustainable construction ($\beta = 1.83$). It is indicated that behavior intention plays a critical role in the application of technology in sustainable construction. There are three angles to analyze this result. First, from the perspective of authority, based on the integration of BIM technology and sustainable construction, strong behavior intention of BIM technology will prompt the authorities to introduce a series of favorable measures to improve the application of BIM technology in sustainable construction, and will form a rational mechanism for long-term development of technology that will optimize the sustainable construction process and generate significant production benefits. From the point of owner, the positive behavior intention will encourage the owner to increase the investment of BIM technology and apply it in practical sustainable construction, such as the establishment of an information gathering platform and information exchange mechanism. In the view of the construction enterprise as the actual application of BIM technology, the behavior intention of BIM technology users directly influences the application of BIM technology in sustainable construction. Since sustainable construction is a new form of construction, there are certain application risks and application obstacles, which make the builders have psychological barriers to the use of BIM technology in the sustainable construction process. Positive behavior intention of BIM technology will enable users to eliminate the psychological exclusion of BIM technology applications in the sustainable construction process, thus contributing to the effective integration of BIM technology and sustainable construction. The effect of the behavior attitude on the sustainable construction is 0.82, which indicates that user’s active behavior attitude can directly affect the efficiency of BIM application in sustainable construction. For example, working attitude is a realistic form of behavioral attitude. A rigorous work attitude will promote working efficiency and project efficiency. Therefore, the positive working attitude of users has a positive effect on the application of BIM technology in sustainable construction. In addition, the actual behavior has a significant effect on sustainable construction ($\beta = 0.76$). It is suggested that BIM users recognize the benefit of the integration of BIM technology with sustainable construction and aim to apply BIM technology in sustainable construction smoothly.

In this study, behavioral attitude, which mainly includes perceived usefulness and perceived ease of use, is also one of the main factors that determines the user’s intention to use new technology. This indicates that behavioral attitudes have a significant effect on the formation of behavioral intention, which affects the application of BIM technology in the operation of sustainable construction. The conclusion is consistent in comparing the TAM (Technology Acceptance Model) and TPB (Theory of Planned Behavior) combined with the analysis of the effect of perceived green value on the public bicycle system [59]. However, the effect of the behavior intention on the actual behavior is only 0.12, indicating that when the intention to use is stronger, it will not be essential for users to put into practice. In other words, because the behavior intention is subject to subjective norms and perception behavior control under other constraints in the ideal state, the behavior intention will obviously be stronger than use behavior. At the same time, the perceptual control behavior and subjective norms have a direct positive effect on the behavior intention. The effect severance is 0.1 and 0.57, indicating that the influence of external subjective normative pressure on behavior intention is more obvious than that of individual perception behavior control. This conclusion is the opposite of Alzahrani’s finding on online gaming behavior among Malaysian undergraduates because the corresponding subject is a negative and needs to be suppressed [60], and is similar to the findings of Si’s findings on bike sharing in sustainable usage [61]. Compared with external pressure, personal perception behavior control has the greatest influence on actual behavior, whereas using BIM technology is a positive behavior that promotes sustainable development, and the influence of passive pressure exerted by the outside world on behavior should be more effective.

7. Conclusions

Investigating the relation between BIM application behavior and the sustainable construction in China’s construction industry has practical significance. The innovation of this study is to analyze the impact of difference parts of BIM application behavior in the process of sustainable construction.
through the theory of improved planned behavior and a questionnaire, thereby bridging the research gap in this field and revealing the current situation of BIM technology in China and the law of user behavior. The conclusion of the study provides management enlightenment of strong feasibility and an important reference value for the authorities and enterprises.

7.1. Findings

The behavior intention, perceptual behavior control, and actual behavior significantly influence one another. Although perceptual behavior control has no direct effect on sustainable construction, it can have an indirect effect through behavior intention and behavior control.

Secondly, behavior attitudes largely determine the behavior intention of BIM users, but when the intention to use is strong, behavior is generated. This path relationship verifies and supports the theory of planned behavior, and also shows that the usefulness and ease of use of BIM technology are the main influencing factors of behavior attitude.

In other words, because the intention to use in the ideal state is constrained by subjective norms and perceptual behavior control, the intention of the users of BIM technology at this stage is obviously greater than the user behavior. Finally, the behavior intention, behavior attitude, and actual behavior significantly influence the sustainable construction. In particular, behavior intention is the largest influencing factor for sustainable construction, and its importance in promoting sustainable construction is well known. Particularly, user’s intention can increase the behavior conversion rate, which enable mandatory policy and normative pressure to help the application of BIM technology. The conclusion of the study shows that the subject of BIM technology promotion should not pay more attention to technology research and development and application promotion. On the contrary, how to improve the conversion rate of product users’ intention behavior is an urgent problem to be solved.

7.2. Management Revelations

The conclusion of this study shows the effect of BIM technology on use behavior and the degree of cognition on the effect of sustainable construction in China, further promoting the positive and stable development of BIM technology as an effective combination with sustainable construction.

Based on the aforementioned research conclusions and summary of user suggestions on the questionnaire, the following management suggestions are proposed at the government, enterprise, and individual levels:

(1) Government level. The finding of this study provides a valuable reference for authorities to formulate legal norms for BIM applications in sustainable construction, incorporating the universal application of BIM technology into the national long-term development strategy plan, which includes BIM technology application standards. This study would prompt the effective application of BIM technology and maximum BIM application value in sustainable construction.

(2) Enterprise level. The relevant enterprises should have a complete understanding of BIM and develop a BIM application plan in accordance with the development prospects of the enterprise, and combine BIM technology application with sustainable construction to conduct the enterprise priority development strategy. Secondly, the technical training of employees should be increased, and training lectures should be conducted so that employees can learn to build sustainable new knowledge relating to BIM technology. In addition, employee skill competitions in BIM technology should be roughly held to help employees to prompt skills in simulation practices.

(3) Personal level. BIM technology users should establish effective value of BIM technology application, thereby increasing perceived satisfaction for BIM technology users and strengthen the intention to application behavior. It is also important for project participants to strengthen psychological construction and enhancing users’ application ability. Similarly, the users should increase active communication with team members and mitigate counteractive emotions, such as improving the formation of their own optimistic psychology to effectively achieve the goal.
8. Research Limitations and Prospects

This study has several limitations. Firstly, the scope of selection of research objects is not comprehensive and the representative is insufficient such that the survey questionnaire has measurement errors. Secondly, BIM technology application projects are large-scale complex projects. Many project participants and stakeholders are involved in a wide range of user-level differences. Thus, the research data used in this study have a certain deviation. In the follow-up study, the sample type is further enriched to improve the research extensiveness of the data source.

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