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DIGITAL CONSTRUCTION TECHNIQUES A REVIEW

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ABSTRACT

Through a systematic literature review we explore the concept of digital transformation in construction. Despite the increasing prevalence of digital technologies and their profound impact on the products and production of the built, such a systematic and longitudinal view of the evolution to the current status of digital transformation, does not exist. The paper contributes by improving our understanding of the current status of digital technologies and their impact of the built environment. The review analyses 3,091 titles and abstracts and 79 full papers. We find that 50% of the studies of the sampled literature on digital transformation were published after 2015. The paper also presents implications of digital transformation with regards to professionals, projects and organisations. Surprisingly, although most of the reviewed sampled studies examine the impact of digital transformation at a project level, the future recommendations and proposed remedies focus on organisational and ecosystem levels. Finally, future directions and suggestions for digital transformation in construction are discussed

keywords : Digital transformation, systematic literature review, innovation, organisations, projects,

I. INTRODUCTION

The construction industry is a large market for new technologies, including digital systems. The global construction technology market is estimated to be worth several billion dollars [1]. However, the process by which a technology is disseminated has been ignored in the building construction literature. The market analytics, including the technology diffusion process, is critical to manufacturers and innovators, and is frequently acknowledged in construction [2–5]. Understanding the details and sequences of the market and the process are important because the construction Buildings 2019, 9, 158 2 of 34 market is subject to booms and collapses. These fluctuations have a huge impact on the innovation process, including the equipment and tool manufacturers, particularly recently established vendors. Despite this, many business reports indicate that new technologies fail at a stunning rate of 40 to 90% [6,7] depending on the technology type [6–8] and due to lack of training, organisation policy, innovativeness of users, and complexity of the technology. These figures demonstrate that technology dissemination strategies, including different strategies of technology demonstration in the construction industry, are a significant phenomenon, which has been reflected in recent studies [2,9,10]. Sophisticated high technologies have been created in an attempt to offer technological solutions to increase safety and productivity and the complicated challenges facing today's construction industry. Previous research [4,11– 19] suggests that new technologies have a large beneficial effect on overall productivity, quality and safety in construction. However, the whole industry continues to be stagnant in technology adoption and the evidence shows that it is generally resistant to change [11,20–25]. For example, the empirical data from the Melbourne Institute of Applied Economics and Social Research [26] shows that the construction innovation index is always significantly lower than all other industries. For example, CAD technology was developed in the 1960s, but its adoption by construction companies mainly took place two decades later in the US, and much later in Asia and other countries. The technology adoption lag and risk aversion to utilising the technologies, which could be called the "adoption paradox", are due to many reasons such as the uniqueness of the technologies [27,28], the variability of vendors and companies' expertise, and the nature of the industry itself [29]. Prior research about technology adoption provides an abundance of theory and evidence regarding how technology is adopted

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[30]. However, very little is known about how the technology dissemination process is initiated, and how the technology itself is demonstrated to the construction and mining markets. Since some technologies are commonly being used in both construction and mining, both sectors them are covered in this study, while the main focus of the paper is the building construction market. The literature shows that there are positive impacts from the use of new and advanced technologies in construction [31–33]. However, there has been no consideration of the adoption influencers and vendor behaviour patterns. In addition, there is no understanding of the difference in demonstrating various technology groups from small hand-tools to advanced digital tools. The paper aims to present strategies used for different technology types, and vendors who are demonstrating these technologies. The paper also aims to provide examples of vendors from different classes based on their demonstration strategies which may affect the adoption process in construction. The paper has three main objectives: (i) defining the concept of technology adoption and different strategies of technology demonstration; (ii) identifying vendors' strategy patterns based on their demonstration activities in the adoption process in the market place. For example, Figure 1 shows how different vendors of heavy equipment successfully attracted many professionals in a construction TE in the US; and (iii) modelling the vendor-customer interactions by identifying key factors. This paper focuses on understanding the varieties of vendors and technologies in construction. While previous research is more INDUSTRY-focused, this research is technology-oriented to present a pattern of demonstration strategies for different technologies in various market places in order to better understand the adoption process. The paper contributes to understand differences in the trajectory of the dissemination and diffusion of different technologies

II. METHODOLOGY

Digital construction techniques refer to the use of technology and software applications to enhance the efficiency and accuracy of civil engineering construction processes. Some of the digital construction techniques used in civil engineering include: Building Information Modeling (BIM) BIM is a 3D digital model-based process that allows engineers and architects to design, construct and operate a building or infrastructure project. It enables collaboration between different stakeholders and streamlines the construction process. Virtual and Augmented Reality: VR and AR technologies are used to create virtual and augmented environments to simulate real-world scenarios, providing a platform to test and optimize designs and construction techniques. Drones: Unmanned Aerial Vehicles (UAVs) or drones are used for aerial surveys, site inspections, and monitoring construction progress. Drones can also capture high-resolution images and videos that can be used for progress reports and marketing purposes. 3D Printing: 3D printing technology can be used to create complex structural components and building materials, offering new possibilities for design and construction. Artificial Intelligence (AI): AI is used to analyze construction data and optimize construction processes. Machine learning algorithms can also be used to predict project timelines and identify potential risks. Internet of Things (IoT): IoT devices can be used to monitor equipment performance, track material usage, and provide real-time data on construction progress. Digital construction techniques can help to reduce construction costs, improve construction speed and accuracy, and enhance collaboration between different stakeholders. These technologies are becoming increasingly important in the construction industry as demand for infrastructure continues to grow, and project complexity increases.

III. PROPOSED VARIABLES AND HYPOTHESES DEVELOPMENT

Technology exhibitions (TEs) are intensive market places that are critical to vendors since they can release and demonstrate their new job-site technologies. At the same time, TEs may support customers to learn about new job-site technologies and collect required information to make their decision to purchase a new construction job-site technology. Thus, analysing observations of TEs enables deep understanding of the existing patterns of vendors' strategies to support the technology adoption process. Our observations consist of field notes, videos, photos, interview records, conversations manuscripts and evidences of their activities such as visual records. In order to analyse the data, a Gauge Matrix [GM] was constructed primarily based on the TE visits, visit notes and unstructured interviews with vendors at the TEs. 38 variables were

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identified across four key indicators to measure vendors business behaviour at the TEs. These indicators cover booth design, communication facility, and technology attributes. The physical design of a booth is an important mechanism for grabbing visitors' attention in a TE. Large booths grab visitors' attention, and well laid out booths are more likely to draw customers in to initiate the adoption process. Thus, display appearance can be a major factor for effective exhibition marketing [73,74] and contributes to exhibition performance [59]. 4.1. Technology attributes and relevant information Technology attributes play a crucial role in customers' decisions and the strategy of demonstrating the technology is very important. Situma [75] explains that large industrial technologies could be exhibited under controlled conditions. Complex job-site technologies usually have their own distinctive characteristics that need specific conditions to be exhibited. Vendors marketing strategies are more likely associated with technology attributes. For example, a tool vendor exhibiting a saw would use a smaller booth than a large mobile crane vendor, which needs a more spacious booth to demonstrate functionality of the equipment, compatibility, attachments, and engine parts. In addition, the leading vendors in each category may demonstrate a series of technologies for different tasks. Most of visitors were interested in product information, with the chief reason given for attending a TE being to search for a new technology. A TriComB2B [76] survey shows that 27% of purchasing persons respond that trade publications are important information sources for purchase decisions. Vendors provide more facilities and training technologies to make it easy to understand compare, Buildings 2019, 9, 158 7 of 34 and choose. Vendors are willing to provide competent knowledge and transfer technical information to all visitors from each stage of the adoption process looking for opportunities provided by a new product. According to Geroski [77] vendors are responsible for facilitating the flow of information about new technologies for marketing. Codified knowledge can be found in technology vendors' manuals. Therefore, thirteen different tactics relevant to technology attributes and disseminating information such as posters and demonstrations are listed in. Using the measures (refer Section 5), vendors were separately scored for each variable. Then, the cluster analysis algorithm was applied to recognise patterns in the sample of vendors and technologies.

IV. CONCLUSION

The purpose of the present research was to extend our understanding of 'technology demonstration' strategies in the construction market. While previous studies have focused on technology dissemination and adoption processes in general, this paper investigated how a technology can be demonstrated. In addition, the paper presented the presents a new framework (PIT) describing construction technology dissemination considering three main strategic aspects: "Physical appearance", "Interpersonal relationship", and "Technology demonstration". While previous studies discussed vendors' and customers' behaviour, they have not provided in-depth information about the way a technology can be demonstrated in the construction industry. In order to analyse the dissemination process for job site technologies in the construction market, we need to identify patterns of vendors and explore their specific and suitable strategies. Three objectives were reviewed in this paper: (i) define criteria for examining patterns of vendors' strategies to support construction companies; (ii) present evidence of different vendors' demonstration methods within different clusters; (iii) give examples of technology groups based on their required demonstration strategies. To accomplish the objectives, vendors' activities of several exhibitions were examined, and the selected booths were analysed using 38 variables with a five-point Likert scale. Then, the hierarchical clustering algorithms were used to classify vendors to explore patterns of vendors' behaviour for supporting technology adoption process. This study departs from previous dissemination investigations in several ways: (1) it looks at the way to assimilate information of new technologies, (2) it investigates how vendors demonstrate their products at different TEs and provides evidence for further understanding of technology demonstration based on such large empirical data, (3) it includes the cluster and thematic analysis of multiple sets of rich data to increase the robustness and generalisability of the results. This paper also presents a valuable research setting for the construction domain, because the technology adoption process is relatively slow [139], and the technology demonstration strategies may positively affect the technology adoption process. The original contributions of the findings of this paper lie in its careful design,

collection of large set of first hand data from various TEs from Australia and North America. In addition, the analysis of selected booths from vendors against the developed criteria to establish a scientifically sound understanding of the technology demonstration in the construction market is based on an innovative research method. A hierarchical cluster analysis showed that the vendors along this spectrum generally fitted into five classes. It is important to articulate the technology demonstration methods in the construction market, as it may affect the construction companies' intention to purchase and utilise a new technology in their projects. Jobsite technology exhibitions are an environment in which technology is demonstrated and related information is assimilated effectively, since TEs focus on a face-to-face environment for communication between vendors and customers. Vendors are able to take advantages of opportunities at these TEs to generate awareness about their products and to impact a company's adoption decision Future directions and research issues were discussed in the paper, and it was suggested that the design taxonomy of physical booths and strategies are also required to communicate with customers. The PIT model also should be verified in different contexts in terms of how contact and relationships are established during preliminary discussions in order to reach the adoption decision. What is the vendors' strategy and procedure in proceeding to support a new customer and allowing them to trial a new technology in a real context? And what are the main factors influencing vendors' booth design and communication strategies? Author Contributions: Samad Sepasgozar designed and conducted the research, and Steven Davis contributed to the interpretation of the data. Funding: This research received no external funding. Conflicts of Interest: The authors declare no conflict of interest

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