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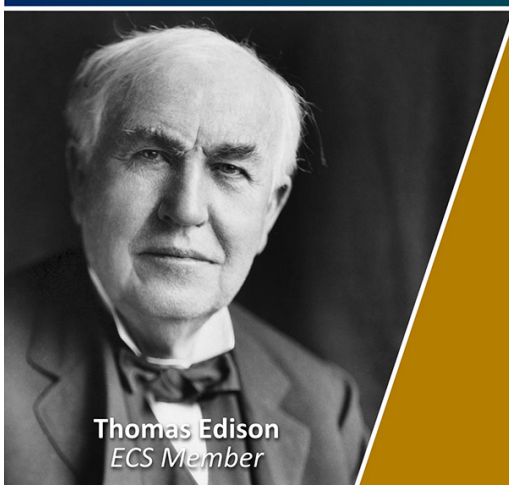
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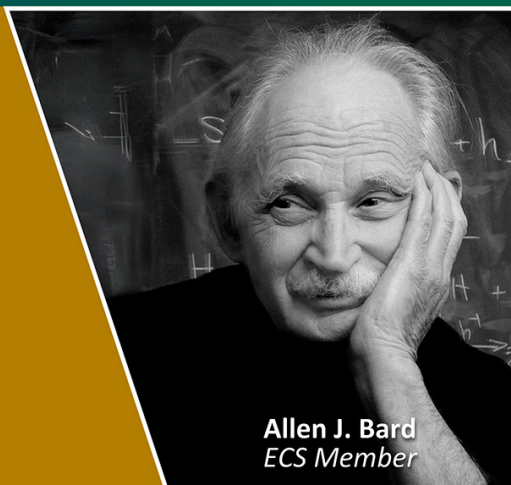
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Real-time Employee Monitoring Technologies in the Construction Sector – Effect, Readiness and Theoretical Perspectives: *The case of New Zealand*

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Abstract. Varieties of Real-time Employee monitoring Technology (REMT) are becoming popular and have aroused significant interest in recent years from the construction sector, where the industry explores the use of advanced monitoring technologies to reduce unsafe work behaviours and improve productivity. However, studies identified some concerns about applying these monitoring technologies at construction sites. Consequently, REMT devices and applications have not been well-received for tracking frontline workers. Lack of understanding of REMT, monitoring data protection and privacy management strategy set a barrier for the monitoring technologies to implement in the construction industry. Privacy has become a critical issue for the future digital construction site. This study adopts the literature review and a questionnaire survey, examined the readiness, summarised effects of REMT applied at the New Zealand construction sites, identified the influence factors, and discovered the theories that will potentially explain the factors and address the potential impact. Communication Privacy Management theory (CPM), Equity Theory (ET) and Control Theory of Privacy (CTP) are reviewed, and a theoretical framework is built upon REMT adoption in the construction sector. In conclusion, future studies are recommended for the international construction entities to get ready to adopt the real-time monitoring tools.

Keywords: Communication privacy management, Effects of worker monitoring, Privacy and data security, Readiness of construction monitoring, New Zealand

1. Introduction

In the post-Covid work environment, various technologies, including contact tracing and behaviour monitoring, have been quickly introduced at construction sites [1, 2]. Real-time employee monitoring technology (REMT), a basic digital infrastructure, can address critical challenges plaguing the labour-intensive construction sector, including low productivity and health & safety issues. REMT also provides a track record of the ongoing building work and real-time information for contractors [3]. However, technologies and applications developed to track frontline workers have not been universally welcomed [4]. The construction sector did not broadly accept REMT, and the development of monitoring technologies has generated pronounced privacy, ethical and behaviour concerns [5, 6]. There is a vigorous debate that exists between employers and employees. Employers consider REMT as a new



norm because safety outweighs privacy. But employees tend to disagree with this proposition and keep requesting open and transparent policies on using these technologies at their worksites. Although a previous study has a theoretical approach on employees' computer monitoring tries to establish a potential solution-based research model, the monitoring environment, functions, and purposes are virtually different from the construction sites. The influence factors and theoretical development of construction frontline worker monitoring remain understudied [7]. This study examines the readiness of REMT currently applied at the New Zealand construction sites and reviews related theoretical perspectives to propose an innovative research framework to guide REMT adoption, balancing the benefits and concerns in a reasonable manner for the construction sector.

2. Literature Review

2.1. REMT in construction

Construction sites have been recognised as having one of the highest accident rates across all work environments [8, 9]. The unsafe behaviour of frontline workers is one of the vital causes of occupational hazards [10]. Real-time employee monitoring technology (REMT) is a powerful and connected tool used for obtaining instant onsite footprints and workers' location and physiological information to identify the potential risks [11]. Research reported traditional integrated tracking technologies are universally applied in worker management systems at construction sites [12]. A case study of Zigbee-based technology was successfully used while constructing a hydroelectric power station, which effectively achieved many functions, such as worker emergency call, safety alerting and location tracking. The evaluation system provided analyses of workers' behaviour to the project safety management. The study showed that onsite tracking accuracy is under 5 metres within the coverage of the construction site [13]. Personal protective equipment (PPE) is commonly used as an effective method to reduce personal injuries at construction sites. However, the problem is affiliated with workers' behaviours, which inappropriately or non-use PPE to create a hazard for projects [14]. Many building companies attempted to use REMT on their PPE in recent years. For example, A case study demonstrated technologies for construction workers to improve safety behaviours and reduce accidents. Figure 1 illustrates the four layers of technologies, sensor, wi-fi network, information management and end-user application, developed for Online Tracking PPE wearable device (TPPE WD). Different sensors are installed in the required worksites in the hardware settings to receive information on whether to use or non-use of PPE by the frontline workers. The data is transferred to the radio transmitter then sent in the IoT concept for central kernel processing. Next, the primary device transmits the processed information to the phone user via a wi-fi module, which builds up a communication platform with their management team. This study showed the frequency of non-use safety equipment decreased after the TPPE WD was installed. The monitoring management system that automatically records the number of non-use of PPE acts as alert or reward tools is essential for REMT adoption [15]. In some cases, even the devices were turned off because of the presence of the equipment, the workers performed safer behaviours and paid more attention to using PPE. This study also found no significant difference between skilled and unskilled workers from PPE use. On the other side, another study showed that workers' acceptance of using REMT has a close relationship with the company's safety management policies, company culture and safety managers playing a critical role in construction health and safety monitoring [16].

The use of REMT in the construction sector has raised concerns from contractors, labour unions, privacy advocates, employment lawyers [17]. REMT users argued that the monitoring benefits to improve productivities are unprovable, but some of the technologies may invade workers' privacy, lead to ethical issues and deteriorate work behaviours [6]. For example, research shows that building companies used monitoring data to reduce labour costs or terminate employment agreements, which causes frontline workers to present counterproductive or unsafe work behaviours due to stress, anxiety, and depression.

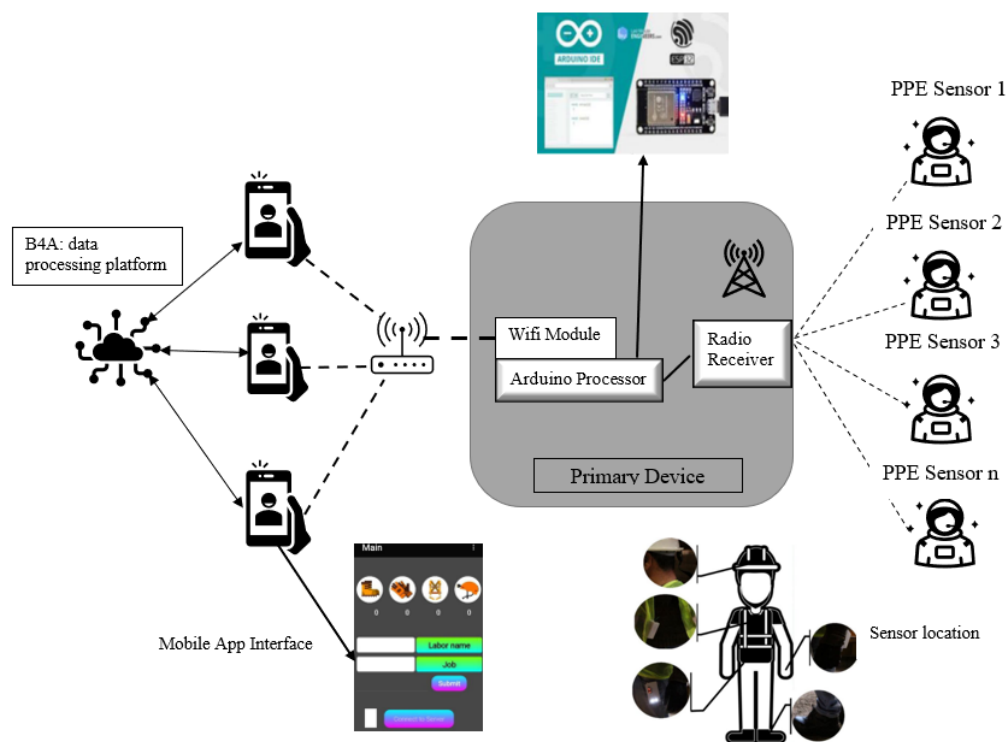


Figure 1. The architecture of TPPE WD

2.2. Theoretical perspectives

Privacy is the fundamental concern of employees, employers and the general public [5]. Previous empirical studies have identified the positive and negative effects in the process of REMT adoption (Freeman, 2003). However, significant ethical and behavioural issues related to employee monitoring also need to be considered [18]. This study reviewed three possible theories in the fields of privacy management, trust management, ethical standards and behaviour control that may apply to the adoption of REMT at the construction site: Equity Theory [19], Communication Privacy Management (CPM) Theory [20], and Control Theory of Privacy [21].

REMT may keep track of the quantity of construction work, but workers may reduce the quality to respond to their undesired attitude to the monitored environment [22]. Equity Theory explains the work behaviours of reducing quantity or quality to rebalance the exchange between employees and employers [18]. Control Theory of Privacy states that online privacy can be seen as a subjective decision-making process where individuals negotiate with the relevant parties to protect personal information [21]. The theory assumes that people form and change attitudes, behaviours and beliefs according to their social context, explaining how people develop and manage relationships in a digital environment [23]. Since the construction industry is steadily moving to the digital era, building company culture and collaboration values play a critical role in REMT adoption [24]. CPM theory describes how people feel about revealing or concealing personal information. Petronio and followers developed an approach that resolves the controversial tension between managing private and publicly shared information [25]. This theory was then applied to investigate its influence on workplace monitoring acceptance [7]. For instance, this research showed that if employers socialise with employees through an informal setting to discuss the privacy boundary, it will help employees develop their understanding of monitoring purposes and actively become involved in health and safety management. Based on this theory, employees will have an improved trust relationship with employers and understand workplace monitoring [7, 26].

3. Research Methodology

This study adopted literature review as a method and used the strategy of Design Science Research [27] to design the research plan, as shown in figure 2.

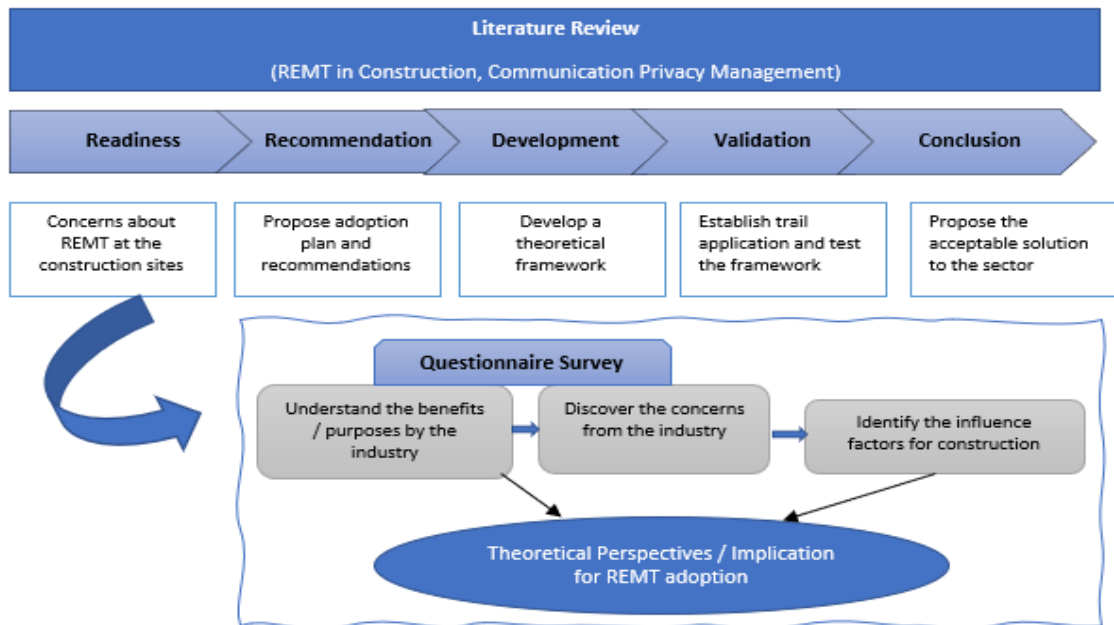


Figure 2. Research design with emphasis on the readiness of REMT adoption

The questionnaire survey has been designed and aimed to examine the readiness of the technologies adoption, identify and validate the benefits and concerns of REMT applied at the construction sites. However, this paper only focuses on the stage of readiness and preliminary theoretical development of REMT adoption in the construction sector. Firstly, The demographic questions were carefully chosen to identify the participants' views about REMT adoption regarding their location, age group, role in construction, work experience and experience of being monitored at their workplaces. These five factors may impact participants' perspectives of REMT adoption in the construction industry. Secondly, the survey determines the participants' readiness to be potentially monitored at the construction sites. A 7-point Likert scale illustrates the degree of agreeableness to assess respondents' willingness, confidence, understanding, awareness, and attitude to REMT installed in their worksites. Thirdly, ten potential benefits and twenty concerns were abstracted from the previous literature review for participants to rate the degree of significance on the scale. Upon completing the survey design, a pilot study was conducted to evaluate its quality and appropriateness, which two senior construction practitioners reviewed. Subsequently, the survey was distributed in the New Zealand construction industry nationwide from June 2021 to elicit responses from participants on their recent views of REMT adoption.

4. Findings and Discussions

4.1. Readiness of REMT adoption

Up to October 2021, 236 valid responses were collected from the New Zealand construction industry. As shown in Figure 3, forty-four per cent of the participants is the frontline trade workers who are the most REMT potential users.

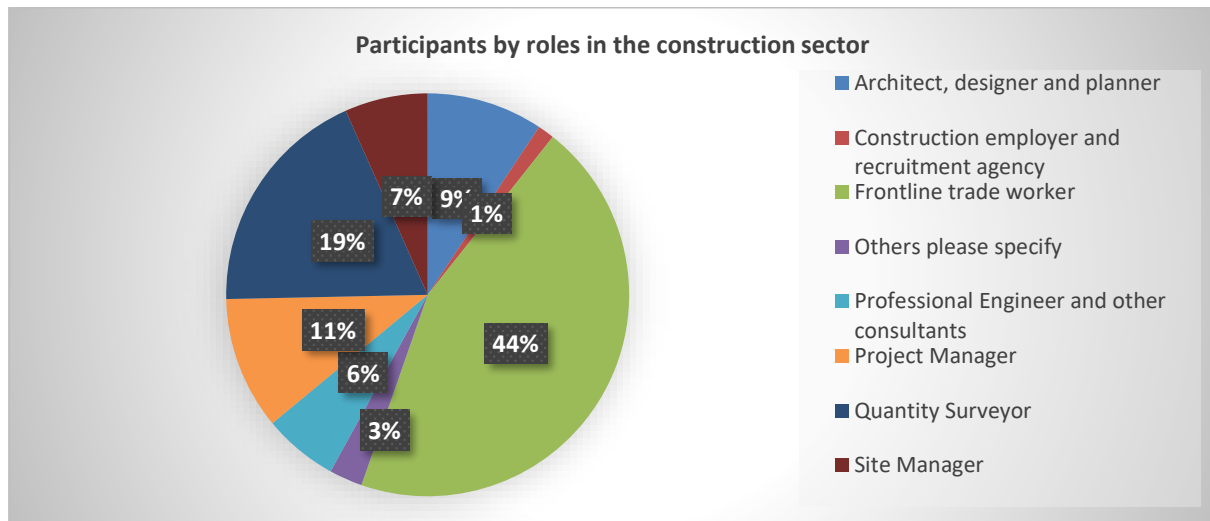


Figure 3. Participants by role in the construction

The age of participants and work experience in the construction industry are the factors that need to be considered. Previous research showed that individuals with different age groups might have different privacy attitudes [28]. For example, the impact of privacy attitudes on protective behaviours among mature workers was more substantial than younger employees. While older age groups consider privacy a right or concern about privacy, they had no impact on their protective behaviour [29]. Figure 4 illustrates the age group and work experience of the participants. This preliminary result shows that middle-aged adults (25 – 45 age group) are the majority, and most participants worked in the industry for more than one year.

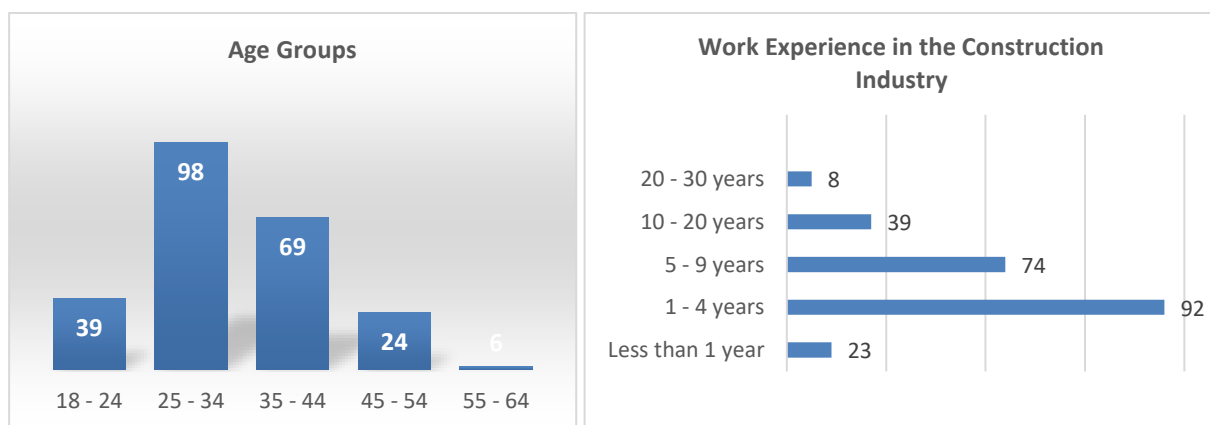


Figure 4. Participants' age group and work experience

The experience of being monitored also will influence participants' views about REMT adoption. A study described that frontline workers with previous experience being monitored at the construction sites showed a higher acceptable level of REMT [30]. However, participants with no similar experience or who do not know much about employee monitoring may not understand REMT fully. As shown in Figure 5, about one-third of the participants do not experience being monitored in their workplaces. In contrast, thirty-seven per cent do not have any knowledge about REMT.

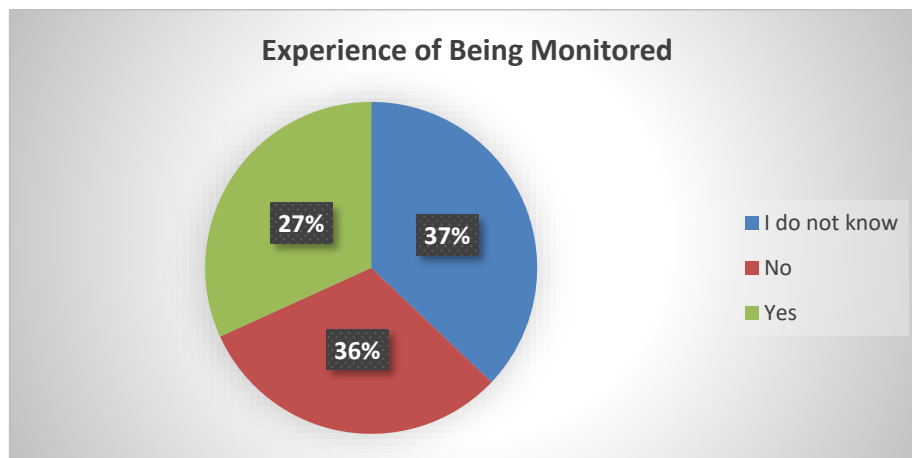


Figure 5. Experience of being monitored

The participants provided numerical scoring expressing the degree of readiness through five statements. Figure 6 shows the mean scores of their rating, (1) means strongly disagrees (not ready), while (7) means strongly agree (ready). The results showed that over half of the participants had rated more than four on the R1, which means they hold a relatively positive attitude on REMT installed at their construction sites and are generally ready to be monitored if employers or authorities require it. Notably, R4, 'I believe employee monitoring increases work efficiency at the construction sites', achieves the highest mean score among the five readiness questions. Most participants consider that REMT can assist them in work efficiency and productivity. Also, R2, 'I accept to trade-off some of my privacy for the company's collective interest', shows positively on the willingness to be monitored for business purposes. Interestingly, the participants expect employers to over control the project budget through REMT (R5 – thirty-five per cent of them were rated less than 4).

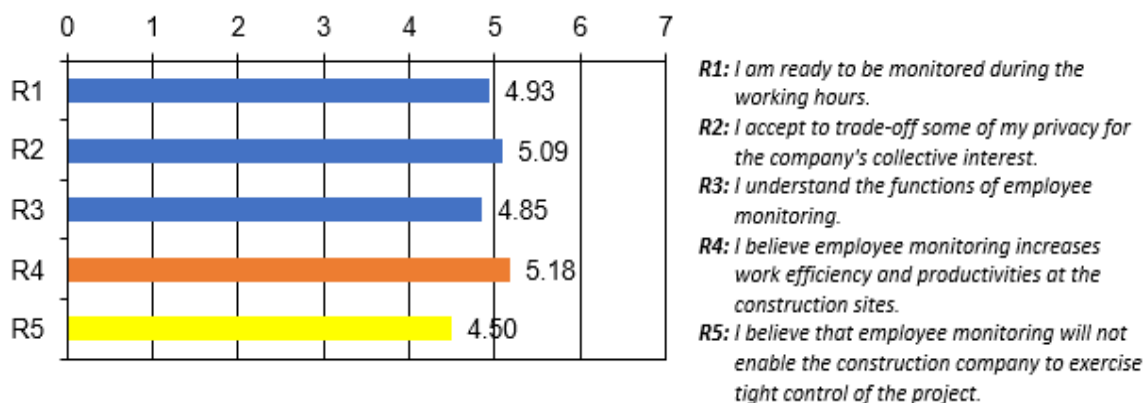


Figure 6. Mean score of REMT readiness

4.2. Effects of REMT and Influence factors for the construction sector

Several empirical studies have identified the positive and negative effects of employee monitoring implementation, which showed a clear relationship with the influence factors and acceptance of REMT [7, 18, 31]. According to the construction industry survey, ten benefits and 20 concerns were available to participants to rate. Relative importance indices (RIIs) are adopted to prioritise the benefits and concerns of REMT, which is widely used in previous studies and was calculated using the following formula [32]:

$$RII = \frac{\sum w}{A \times N}, (0 \leq RII \leq 1)$$

In this formula, “w” is the weighting given to each benefit or concern statement by respondents and ranges from 1 – 7 (1 being strongly disagreed or not significant and 7 being strongly agreed or most significant), “A” is the highest weight and “N” is the total number of the sample. The preliminary results showed the top 5 RII ranking of positive and negative effects and summarised in table 1.

Table 1. REMT effects by ranking

RII Ranking	Positive Effects	Negative effects
1	Improve building site resource allocation and productivities	Undefined monitoring purposes lead to dissatisfaction with the monitored work environment
2	Improve construction site security	Employees' legal and privacy rights damaged in the employment relation
3	Reduce unsafe work behaviours and avoid construction site accidents (e.g., fire)	Inaccurate, inconsistent and incomplete data collection may cause unfair decision making
4	Enable quick emergency responses	Inappropriate or abusive use of employee's data
5	Create a healthier and safer work environment	Distrust work environment, mental health issues and low job performance

Although most studies of REMT share a focus on the effects of employee monitoring, they take various approaches on the influence factors or causal relationships between REMT and the effects. Based on the literature review and the preliminary results of the construction industry questionnaire survey, this study has identified five influence factors illustrated in Figure 7. Age, monitoring experience and understanding of REMT are tangible factors influencing users' perspectives on the adoption. The younger age group and people with monitored experience showed higher acceptance levels. Also, they have presented a better understanding of monitoring technologies, purposes and benefits of REMT. Some intangible factors affect the technologies adopted in the construction sector, including building company culture and industry ethical standards, trust between contractors and workers, work commitment, and behaviour patterns.

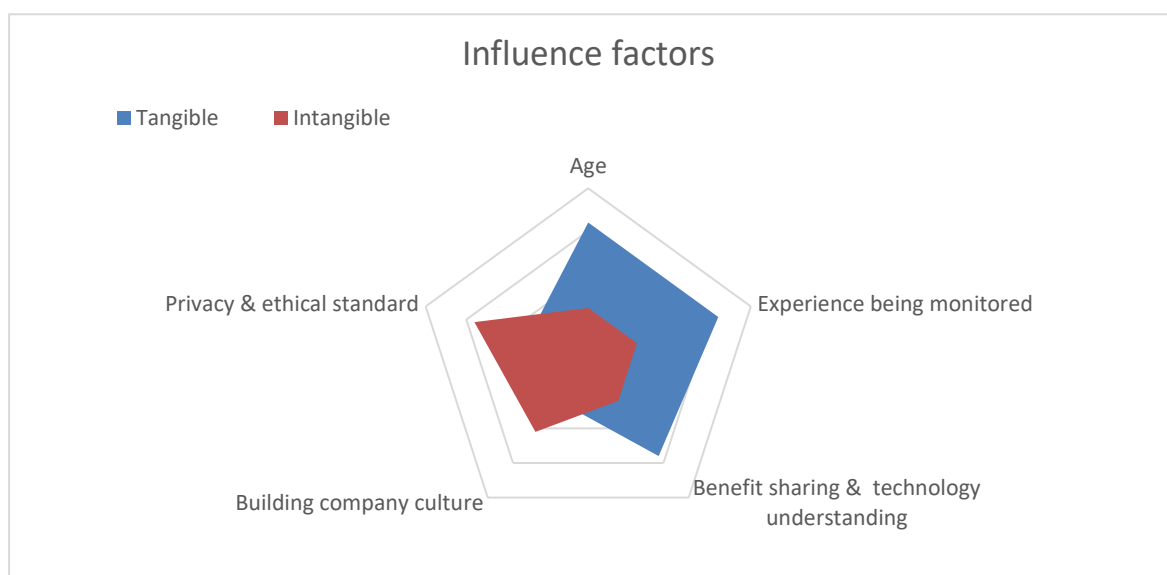


Figure 7. Influence factors on REMT adoption

4.3. Theoretical Framework

Considering the influence factors in the construction industry, the study on theoretical perspectives offer a comprehensive framework for understanding private information management, communication strategy, industry ethical standards and designing a prototype to address or balance concerns in the construction sector. As a result, a preliminary theoretical framework is presented in Figure 8.

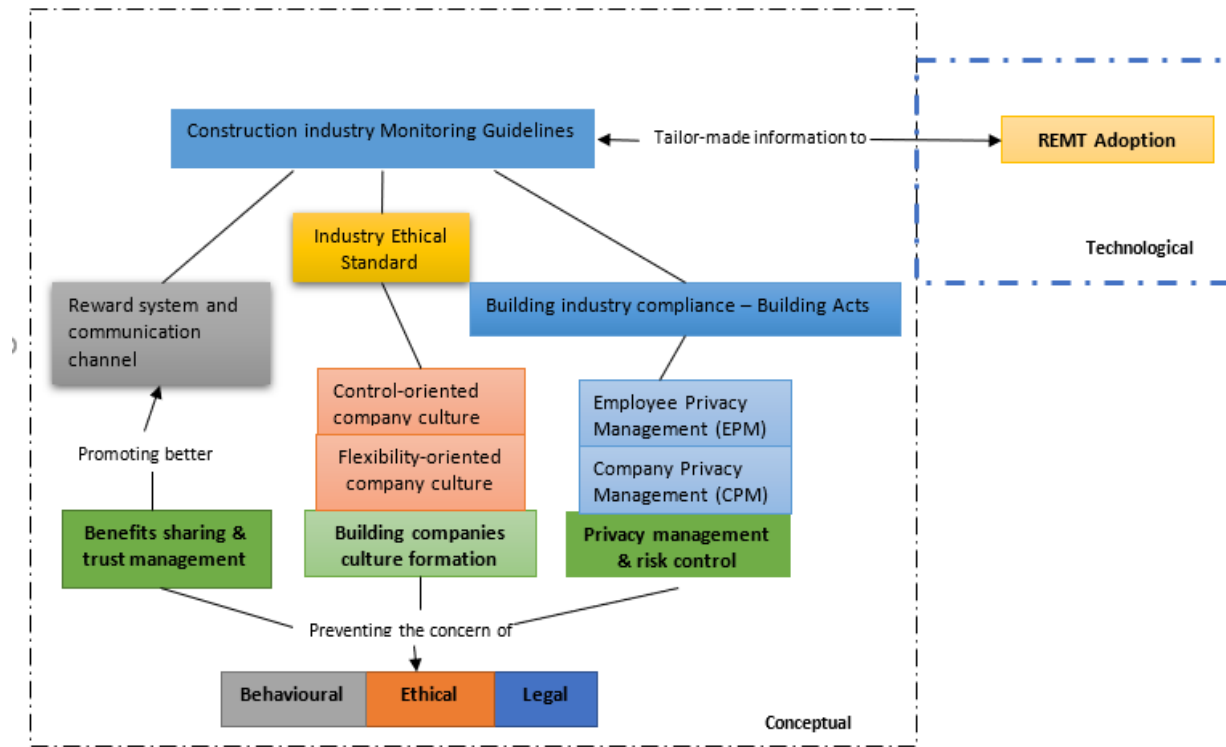


Figure 8. Preliminary theoretical framework

5. Conclusions and Future Research Area

The development of REMT with an increasingly sophisticated system gathers multitudes of data across different industries and work environments. The global construction sector intends to receive more support from monitoring technologies, which can help with critical challenges, such as low productivity and health & safety issues. This study reviewed a REMT application used at the construction sites, demonstrated the effectiveness of technologies in improving productivity and safety management, and sought to find the positive and negative effects. The theoretical approach explains and addresses the concerns and negative impacts. The industry survey has been adopted to validate the readiness and challenges of REMT for the New Zealand construction sector. However, this study is limited to measuring indicators of effective use of the monitoring technologies. In-depth data analysis, including cost and benefit analysis, factor analysis, and investigating the relationship between benefits and concerns (Structure Equation Model), is expected in future studies. Five effects and influence factors have been identified to establish a baseline for the technology users. A trail monitoring equipment will be installed at a New Zealand based construction site, and further data will be collected in the following phase of this study. Based on this study's findings, a preliminary theoretical framework has been established, including building company culture, privacy management, risk control, REMT benefit-sharing, and trust management, which are the elements to cross-testing in the process of trial. This paper proposes future research on detailed validation to verify the theoretical framework. It is hoped that the theoretical approach will provide research direction for researchers developing REMT adoption best practice guidelines for the global construction sector.

6. Acknowledgement

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