Benefits and barriers in uptake of mobile apps in New Zealand construction industry: What top and middle management perceive

Liu, Tong; Mathrani, Anuradha; Mbachu, Jasper

Published in:
Facilities

DOI:
10.1108/F-08-2017-0078

Benefits and Barriers in Uptake of Mobile Apps in New Zealand Construction Industry: What Top and Middle Management Perceive

Abstract

Purpose:

Mobile apps offer construction workers a quick, affordable and user-friendly platform for meeting their information, communication and computing needs, with nearly 13,000 construction apps currently available in the market. This study reports construction managers' perspectives on the uptake of mobile apps in the New Zealand construction industry.

Design/Methodology/Approach

Exploratory research methods were used in two stages. First stage involved interviews with 14 construction managers who were registered with the New Zealand Registered Master Builders Association followed by an online questionnaire in the second stage. The link of online questionnaire was sent to all members of participating professional organisations by their administrators. 228 responses were received in total, of which 60% participants completed the entire questionnaire.

Findings

Results show an overall positive attitude towards the use of apps. Perceptions of top management personnel differed slightly from those of middle managers; the former expressed interest in apps usage at strategic level such as improving long-term client relationship management and satisfaction; while the latter were more interested in the apps use at operational and tactical levels such as task- or project-level productivity improvement.

Research limitations/implications

Though bias has been minimised by giving equal opportunity to each member of trade and professional organisations to participate in this survey, of the 228 responses received, only 60% participants completed the entire questionnaire. This is below the minimum requirement for a holistic representation of views. As a result, the findings might not be generalised beyond the study's scope.

Originality

The study provides new insights on the uptake of smartphone apps in New Zealand's construction sector from the perspective of construction managers who make strategic

decisions. The findings have implications for policy formulation and implementation in regards to the use of mobile apps for productivity improvement in the sector. Mobile apps developers could also gain understanding on functional needs and preferences of the construction workforce, which will help in development of more relevant apps.

Keywords: Director; CEO; Senior Management; Project Manager; Construction Manager; Site Manager; App; Construction; Productivity; Mobile; Smartphone

1. INTRODUCTION

Much like other industry environments, the construction workplace is influenced by technological, managerial and local perspectives, although there are some inherent differences within this sector. The construction worker is not confined in a specific workplace surrounded by regular office equipment like desks and computers; rather construction professionals are mostly on the move working at one building site or another. Their tasks are focussed on improving facilities involving physical movements such as measuring energy performances of buildings, analysing tools and their utilities at building sites, examining building materials, planning affordable housing in view of climate conditions, or, in other words developing sustainable development practices (Nielsen, Sarasoja & Galamba, 2016). Hence, construction professionals do not fit in the general label of a nine-to-five office worker. However, this is not to say that construction professionals are technologically challenged. Technology has pervaded into almost every adult's professional life. Smartphones have become an essential part and is the most frequently used computing device amongst others (e.g. notebook, PC and feature phone) with 91% of smartphone users reporting that they use their smartphone every day (Research New Zealand, 2015). A smartphone not only provides traditional communication functions like making phone calls and texting, but also delivers computing facilities since it is built on advanced operating systems similar to those used in computers.

A plethora of apps (which is a quick-and-easy way to say mobile applications or software programs developed to run on smartphones) have pervaded our lives. There were 2.8 million Android's apps and 2.2 million Apple's apps available to be chosen in leading app stores in March 2017 (Statista, 2017). It is estimated that there may be nearly 13,000 construction related development and design apps currently available in the market (Yovino, 2013). The apps currently available in the market offer a range of functionalities from simple calculations to detailed architectural renderings (Top Apps, 2013). Despite the increasing proliferation of apps within the construction industry, little information is available on the value of the mobile apps to the workforce (Ministry of Business Innovation & Employment, 2015). Bowden *et al.* (2005) recommends using smartphones (or mobiles) for faster data collection and exchange thereby improving workflow efficiency. The top management roles, director and CEO works towards identifying environmental opportunities and related problems, interpreting relevant information, considering organizational capabilities and constraints, and formulating strategies to improve workplace productivity (Mintzberg, 1979). The middle management roles, project/construction/site managers are responsible for managing the full project lifecycle from assisting with the bids, setting and starting up of the projects, agreeing to meeting deliverables with external stakeholders, managing the project's program, motivating their project team to deliver and finally handing over the project. The top and middle management personnel are the main decision makers in the construction industry; hence we decided to explore their perspectives on uptake of

mobile apps.

The purpose of this paper is to develop a comprehensive understanding on benefits and barriers of the uptake of mobile apps in the New Zealand construction industry from a management perspective. Can apps be utilised by construction professionals at tactical, operational and strategic levels to improve the workforce productivity? We conducted exploratory surveys with 14 members of the New Zealand Registered Master Builders (RMB), followed by questionnaires with management in the construction sector to gauge their views in this matter.

This section has laid the background of our research inquiry. The remainder of the paper is organised as follows. The next sections discuss relevant literature, including productivity measures, an overview of the New Zealand construction sector, existing mobile app technologies and their benefits and barriers. Subsequently discussions are focused on the research methods adopted, including the target population for sourcing the empirical data. We then discuss the analytical process and present the results of our analysis. The conclusions, limitations and future research direction are presented in the final section.

2. PRODUCTIVITY MEASURES IN THE CONSTRUCTION SECTOR

Productivity is a measurement of inputs and outputs of resources, though in construction it can have multiple meanings (Kenley, 2014). Productivity measures at firm level include management (e.g., workflow reliability), tools and the automation and integration of information systems at strategic and operational levels (Kenley 2014). The way a project is managed and the way activities are planned and controlled are managed at a tactical level. Davis (2007) has described productivity at three levels, namely, onsite (i.e., activity scheduling, material supply and design), firm (i.e., practices for managing projects) and industry (i.e., skills, investment, competitive advantage and regulation). Yi and Chan (2014) define productivity from three perspectives, namely, activity (i.e., workflow tasks), project (i.e., tools and machinery used to integrate the tasks) and industry (i.e., skills, training and standards). Kenley (2014) consolidates Davis (2007) with Yi and Chan to four levels in the construction process: industry, firm, project and activity.

Currently there is limited research to inform practice on how to make productivity measures and gains. Industry level productivity claims are made at macro-level, such as average age of workforce, quality of services and country's resources. Firm level productivity looks at organizational level, production cost and capital available. Project level productivity looks at controls put in place to monitor performances at sites to avoid deviation from plans, and activity level looks at the individual worker's productivity (Kenley 2014). Some of the key performance indicators (KPIs) to improve productivity are identified as cost, flexibility, speed, time, dependability, quality, client satisfaction, change orders, business performance and health and safety (Tangen, 2005;Slack,2005; CAENZ, 2008; Beatham, 2004). Research in general identifies productivity interventions to be made to the underlying business processes at the strategic, operational and tactical levels. They propose investments to be made in information and communication technologies (ICTs) to help improve workforce productivity by applying appropriate control models for improving the quality of services, using automated data collection technologies (e.g., GPS, RFID) and ensuring worker safety amongst others (Lingard, 2013, Kenley, 2014).

3. NEW ZEALAND CONSTRUCTION SECTOR

The construction sector in New Zealand employs over194,000 people and is a key driver of economic growth with annual revenues of $30 billion plus (Ministry of Business Innovation & Employment, 2015). However, productivity within construction industry is low compared with other economic sectors such as agriculture, forestry manufacturing and service industry ((Page and Norman, 2014). The construction industry is one of few industries which has dragged down New Zealand's aggregate productivity growth performance (Conway and Meehan, 2013), and the government has identified productivity growth as a priority (Ministry of Business Innovation & Employment, 2015).

To better understand, the current job descriptions of a typical construction worker, we next conducted a search on careers and job websites in New Zealand (Careersnz, 2017, Seek, 2017). Some of the tasks listed for construction professionals are, overseeing site activities, delivering high-quality projects, preparing budget estimations, resolving building issues, maintaining health and safety standards, developing quality assurance plans, controlling construction costs, selecting proper building material and equipment, ordering materials, tracking inventories, preparing site reports, and managing client and external parties (e.g., subcontractors, suppliers).

4. CURRENT APPS IN CONSTRUCTION SECTOR

The market for mobile devices is growing steadily. Smartphones and tablets are considered handy devices with its bundled apps providing different types of computing services. Moreover mobile devices offer targeted communication, whereby messages can be delivered are in a straight and concise format between the user and the mobile device (e.g. smartphone, tablet, PDA) without the extra frills (like big file size, report headers, etc.) which are present in computer-based applications. Hence, mobile computing offers construction workers a quick-and-simple platform, devoid of technical details, to help them communicate relevant on-site information to other stakeholders situated in different locations. Moreover smartphones also offer portable camera functionality, which is not always available through other desktop devices.

In a previous study (Liu *et al.*, 2016), we explored 519 mobile app recommended by 9 online recommender websites. For example, recommender site Capterrra listed 237 apps, Software Advice listed 185 apps, SmartbidNet listed 20 apps, Daily Reporter listed 58 apps, the Balance listed 10 apps, and tSheets listed 9 apps. The popular apps recommended by more than one recommender site are PlanGrid (for collaboration management), JobFlex (for estimating and tendering software), Procore (project management) and SmartBidNet (for bid management). They are all cloud-based, available both in iOS and/or Android platforms (Liu *et al.*, 2016).

After the first stage in-depth interviews, we identified the apps used in New Zealand construction industry including BuilderTREND, Procore, PlanGrid, Co-construct, 360 Panorama, BuildIT, Basecamp, Harvest, Timelines, Workflow max, BIMx, Aconex, Builders Buddy, Adobe Photoshop, ZeroHarm, JobFLEX, CONQA, Corecon, T-Sheets, Box, Dropbox, Xero, MetService, HazardCo, BuilderTREND, My Inspection, MYOB, iAuditor, BIMx, LocknLoadHub, Handyman Calculator and AutoCAD 360. These

mobile apps range from project management, calculators, safety, integrated construction cost and accounting, construction site operations, computer aided design (CAD), estimating, and building information modelling (BIM).

5. BENEFITS OF USING MOBILE APPS

Previous research conducted in USA and India found that mobile apps can increase productivity in construction industry (Bowden et al., 2006, Sharma and Gupta, 2014). Research conducted on USA jobsites found that the mobile solutions have impact on quality, subcontractor management, site coordination, safety, productivity, material procurement, project duration, and budget (Azhar and Cox, 2015). Bedard (2013) suggests mobile technologies can help all phases of the construction process to work seamlessly and keeping costs under control. The outcome from first-stage of the investigation led us to ascertain eight benefits in use of apps by construction professionals. These are B1: more efficient management of checklists, documentation and sign-offs, B2: more accurate customer invoicing and real time tracking for prompt payments, B3: more efficient employee or subcontractor timesheet management, greater visibility into workforce productivity, performance monitoring and evaluation, B4: better client relationship management and satisfaction, B5: greatly reduce liability and risks through accurate and prompt compliance reporting, B6: ability to more accurately and efficiently price and track change orders, B7: greatly improve efficiency and accuracy of site inspections and reporting, and B8: overall improvement in productivity and profit margin on the job.

On the basis of insights gained from the literature (Bowden *et al.,* 2005) and the outcome from first-stage, we have proposed that productivity and profit margin could be improved (B8), if mobile apps could achieve the benefits from B1 to B7 (refer Figure 1).

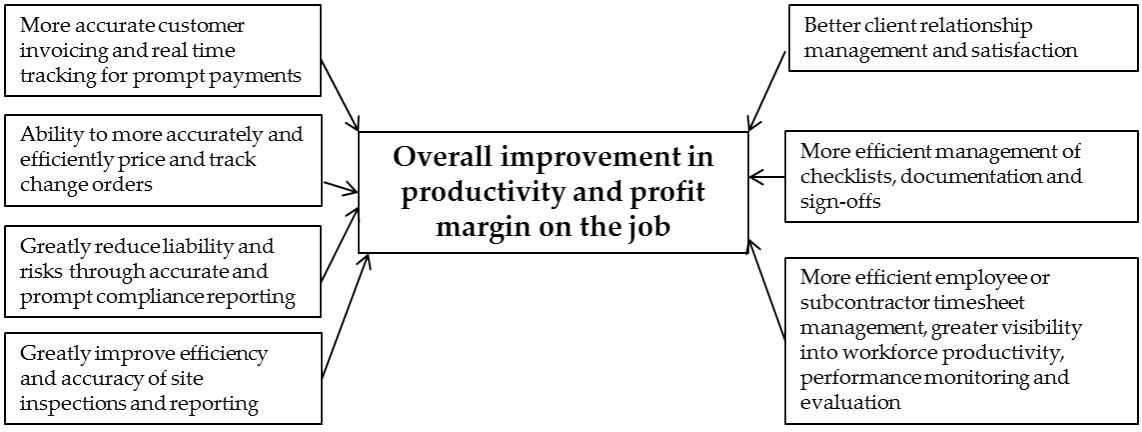

Figure 1. Benefits and overall improvement in productivity of the uptake of apps

6. BARRIERS IN UPTAKE OF MOBILE APPS

Participants from USA construction industry suggested that there was often not enough

time to learn or train users on current use of the mobile devices (Sattineni and Schmidt, 2015). The construction industry is booming in New Zealand. Finding time for construction professionals to learn new IT skills could be a challenge. Without IT knowledge, adopting mobile technology such as mobile apps could be a challenge. A steep learning curve might be required to make use of mobile apps efficiently. Lack of IT knowledge, cyber security concerns could arise especially sending classified information to cloud, remote servers hosted on the Internet (Silverio et al., 2017).

In USA, older construction workers are reluctant to change (Sattineni and Schmidt, 2015). Australian construction sector has also highlighted the slow and reactive nature regarding business practices/process changes (Gajendran and Perera, 2017)

A survey conducted in USA jobsites found that the cost of training, cost of hardware maintenance, software licensing fee, and connectivity issues are main barriers of wider adoption of mobile solutions (Azhar and Cox, 2015). In New Zealand, a mobile device is not cheap. 128GB Apple iPhone 7 costs over $1000 (PriceSpy, 2017). Similar costs are for a 128GB Google Pixel Android phone (PB Tech, 2017). Further, mobile devices could be too fragile for rugged construction environment. The screen of mobile could easily break when dropped face down on concrete. The cost of replacing the screen could be as much as $200 in New Zealand.

There are many commercial or proprietary apps which licensing fees applies, while there are also many free apps available on the current market. However, many of these free apps have limited functionality and are buggy (Sattineni and Schmidt, 2015).

The following barriers are also identifies from our first stage in-depth interviews in New Zealand construction sector:

- No time to learn
- No need to learn
- Too difficult to learn
- Mobile devices are too expensive to buy or fix
- Apps and licensing fees are too expensive
- Training is too expensive
- Security concerns (safety of classified data)
- General industry attitude and reluctance to change

7. RESEARCH METHODS ADOPTED

We conducted an investigation on the attitude and barriers of uptake of construction apps in New Zealand construction sector as perceived by the top and middle management. The investigation comprised two stages. In the first stage, an exploratory study comprising interviews to gauge attitudes towards apps in general was conducted with 14 key members of New Zealand Registered Master Builders. The criteria of selecting of interviewees included management role, years of construction industry experience, business areas, etc. The choice of this research method was justified on two grounds. Firstly, exploratory surveys are suitable for research where the aim is to generate constructs or theories which will be validated in future quantitative research (Zikmund, 2013). Secondly, the method is suitable for empirical data that are qualitative in nature and for which scale of measurement is ordinal (Bryman and Bell, 2015). The convenience sample of 14 members was in line with the exploratory nature of the study,

that is, to explore social phenomenon as against quantitative experimentation. While the sample size used was small, the interview-based in-depth qualitative exploration provided rich insights on benefits and barriers to the use of apps in the construction sector.

In the second stage, based on feedback from the first stage and insights gained from previous research studies (Ikediashi *et al.*, 2016, Azhar and Cox, 2015), we designed a questionnaire. The questionnaire was pre-tested, and re-worded for clarity and relevance, based on feedback from industry professionals prior to delivering to the whole sampling frame. The questionnaire was designed to be completed in about 20 minutes. It was then hosted online and link was provided in emails requests sent to the members of the New Zealand Registered Master Builders (RMB), Licensed Building Practitioners (LBP), New Zealand Institute of Building (NZIOB) and New Zealand Institute of Architects (NZIA). Construction professionals were assured of their confidentiality and anonymity with only the researcher team having access to the survey responses. The questionnaire was divided into two sections. The first section was used to collect data about the respondents' perceptions of the benefits and barriers of adopting mobile technology in the New Zealand construction industry. Those survey questions were ranked using the Likert scale from largest (5-strongly agree) to smallest (1-strongly disagree): degree of agreement and disagreement. The second section of the questionnaire looked at their demographics like respondents' status in the company. Due to the fact the participating trade and professional organisations are reluctant to provide information of their members because of the privacy reasons and business secrets, this study adopted census survey instead of basing the required number of survey participants on the representative minimum sample size. Use of census survey also gives all participants equal opportunity to participate. The questionnaire was hosted online and a link was provided in email requests to all the members by their professional organisations' administrators. 228 responses were received in total. Although the number of participants may seem small, all the members of sampling frame were given the chance to reply. Out of 228 responses, only 137 participants completed the entire questionnaire. Most of participants who did not use apps did not answer the questions of benefits and barriers of uptake mobile apps.

The search inquiry moved next to understand top and middle management group view on benefits and barriers towards uptake of apps in the New Zealand construction industry context. To determine whether the means of two independent groups differ, 2-sample t-test is used in this analysis. The top mangers' view of benefits is compared with middle managers' view. Structural equation modelling (SEM) is used to determine whether a certain model is valid (SPSS, 2012), especially when it involves a certain exploratory element. To explore and validate causal relationships between perceived benefits of mobile apps and its perceived contribution to productivity improvement in the New Zealand construction industry, we applied SEM to test our model shown in Figure 1.

8. RESULTS

This section presents the results of the questionnaire survey. In total 228 responses were received, 137 completed the entire survey. Of these 56.92% of the participants were in the top management having roles such as CEO or director in their company, while 30% were in the middle management having roles such as project/construction or

site manager. The rest of participants were quantity surveyors, quality control, building official, engineer and architect.

8.1 Perceived benefits of app use

Survey respondents were asked to rank their agreement/disagreement to the potential benefits (B1-B8) offered by mobile apps as had been revealed from the stage one study. Next, we have compared the means of responses for the benefits (B1-B8) between top manager and middle manager (refer Table 1). There appears to be not much difference in views between the top managers (Director / CEO / Senior Management) and the middle managers (Project/Construction / Site Manager) towards the benefits provided by mobile apps (since all p values are greater than 0.05).

Table 1. Two-Sample T-Test results of perceived benefits of the use of mobile technology

Benefits of the use of mobile technology	**Top Manager (mean)**	**Middle Manager (mean)**	**P**
B1: More efficient management of checklists, documentation and sign-offs	3.709	3.769	0.759
B2:More accurate customer invoicing and real time tracking for prompt payments	3.445	3.553	0.560
B3:More efficient employee or subcontractor timesheet management, greater visibility into workforce productivity, performance monitoring and evaluation	3.547	3.538	0.966
B4: Better client relationship management and satisfaction	3.560	3.821	0.133
B5: Greatly improve efficiency and accuracy of site inspections and reporting	3.596	3.615	0.914
B6:Ability to more accurately and efficiently price and track change orders	3.385	3.667	0.140
B7:Greatly reduce liability and risks through accurate and prompt compliance reporting	3.442	3.538	0.596
B8:Overall improvement in productivity and profit margin on the job	3.283	3.553	0.162

Next, all rated values of benefits were added together for applying the Two-sample test. Our results show there is a significant difference in views between the top managers and middle managers towards the benefits the mobile apps might provide (since the p value is less than 0.05). The middle managers are more positive in their views about the benefits provided by mobile apps (refer Table 2).

Table 2: Two-Sample T-Test Results of total perceived benefits of the use of mobile technology

Benefits of the use of mobile technology	**Top Manager (mean)**	**Middle Manager (mean)**	**P**
Total Benefits	25.26	28.87	0.008

8.1.1 Benefits: top manager's point of view

Next we used the analysis of moment of structures (AMOS) based structural equation modelling routine to validate the causal relationships between the perceived benefits and the perceived overall productivity improvement. Validity has been checked by examining the extent to which developed model fitted the estimated covariance matrices of the dataset. Benefits as perceived from the top manager's view are shown in Table 3.

Table 3: Regression weights of perceived benefits of the use of mobile app from top manager's point of view

B8 <--- B (B1, B2, B3, B4, B5, B6, B7)	**Estimate**	**S.E.**	**C.R.**	**P**
B8 <--- B1 (More efficient management of checklists, documentation and sign-offs)	.219	.084	2.600	.009
B8 <--- B2 (More accurate customer invoicing and real time tracking for prompt payments)	.097	.082	1.177	.239
B8 <---B3 (More efficient employee or subcontractor timesheet management, greater visibility into workforce productivity, performance monitoring and evaluation)	.159	.079	2.016	.044
B8 <--- B4 (Better client relationship management and satisfaction)	.330	.085	3.866	0
B8 <--- B5 (Greatly reduce liability and risks through accurate and prompt compliance reporting)	.122	.086	1.421	.155
B8 <--- B6 (Ability to more accurately and efficiently price and track change orders)	.016	.089	.177	.860
B8 <--- B7 (Greatly improve efficiency and accuracy of site inspections and reporting)	.119	.091	1.307	.191

The figures in Table 3 indicates that the p-values of the relationship between B8 (use of mobile apps to improve overall productivity and profit) and B4 (better client relationship management and satisfaction), B1 (more efficient management of checklists, documentation and sign-offs) and B3 (more efficient employee or subcontractor timesheet management, greater visibility into workforce productivity, performance monitoring and evaluation) are less than the critical alpha value of 0.05. Therefore B8 is significantly related to B1, B3 and B4. These relationships for top managers are illustrated in Figure 2.

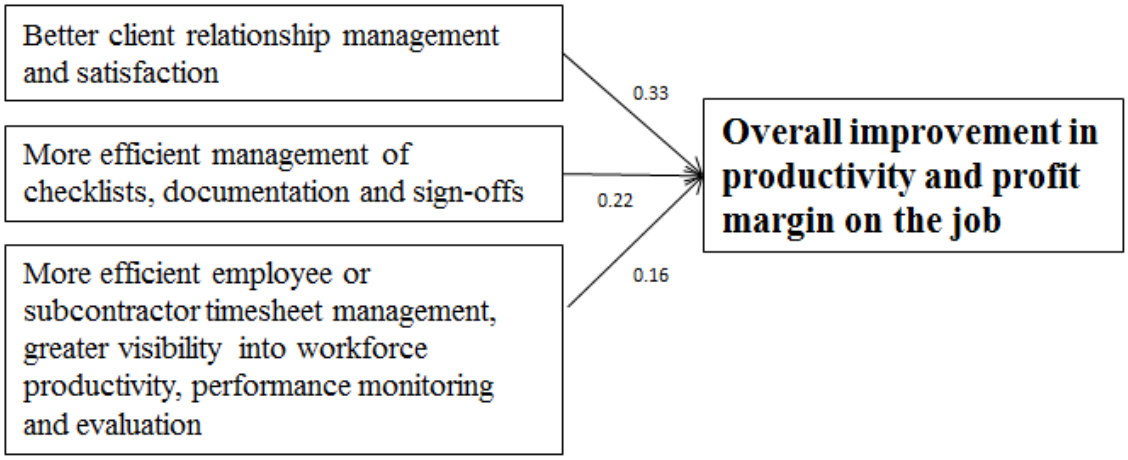

Figure 2. The structural equation model showing benefits from top manager's point of view

8.1.2 Benefits: middle manager's point of view

The AMOS-based structural equation modelling was next used to validate the causal relationships between the perceived benefits and the perceived overall productivity improvement from the middle manager's point of view (refer Table 4).

Table 4: Regression weights of perceived benefits of the use of mobile app from middle manager's point of view

B8 <--- B (B1, B2, B3, B4, B5, B6, B7)	**Estimate**	**S.E.**	**C.R.**	**P**
B8 <--- B1 (More efficient management of checklists, documentation and sign-offs)	.226	.086	2.626	.009
B8 <--- B2 (More accurate customer invoicing and real time tracking for prompt payments)	.064	.095	.672	.501
B8 <---B3 (More efficient employee or subcontractor timesheet management, greater visibility into workforce productivity, performance monitoring and evaluation)	.288	.086	3.335	0
B8 <--- B4 (Better client relationship management and satisfaction)	.004	.114	.039	.969
B8 <--- B5 (Greatly reduce liability and risks through accurate and prompt compliance reporting)	-.014	.098	-.141	.888
B8 <--- B6 (Ability to more accurately and efficiently price and track change orders)	.003	.093	.029	.977
B8 <--- B7 (Greatly improve efficiency and accuracy of site inspections and reporting)	.492	.095	5.185	0

Above figures in Table 4 indicate that B8 (or use of mobile technology to improve overall productivity and profit) is significantly related to B7 (greatly improve efficiency and accuracy of site inspections and reporting), B1 (more efficient management of checklists, documentation and sign-offs) and B3 (more efficient employee or subcontractor timesheet management, greater visibility into workforce productivity, performance monitoring and evaluation) because the p-values are less than the critical alpha value of 0.05. The relationships for middle managers are illustrated in Figure 3.

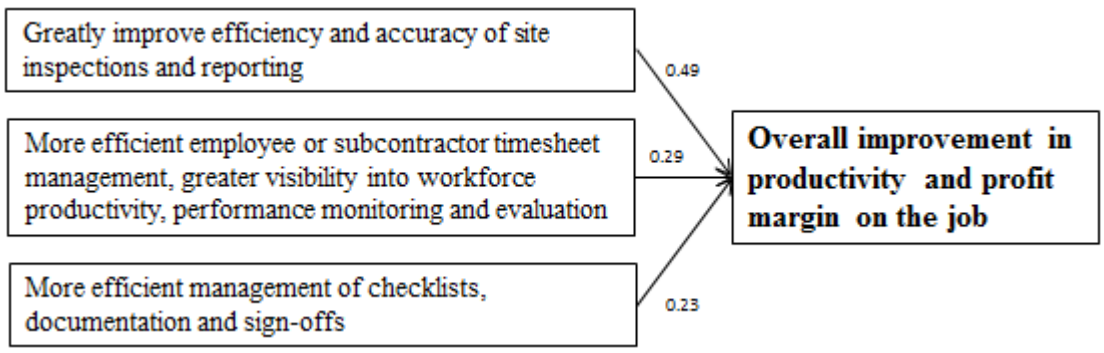

Figure 3. The structural equation model showing benefits from middle manager's point of view

8.1.3 Benefits: top and middle manager's point of view

Combining the AMOS-based validations from top and middle managers views, we see that top managers are concerned most about the aspects related to client relationship management and satisfaction (B4), while middle managers are concerned with inspections and reporting (B7). Both top and middle managers agree that B1 (more efficient management of checklists, documentation and sign-offs) and B3 (more efficient employee or subcontractor timesheet management, greater visibility into workforce productivity, performance monitoring and evaluation) contribute to overall productivity by using the apps. The views of middle management are shown on left side and that of top management on the right side in Figure 4.

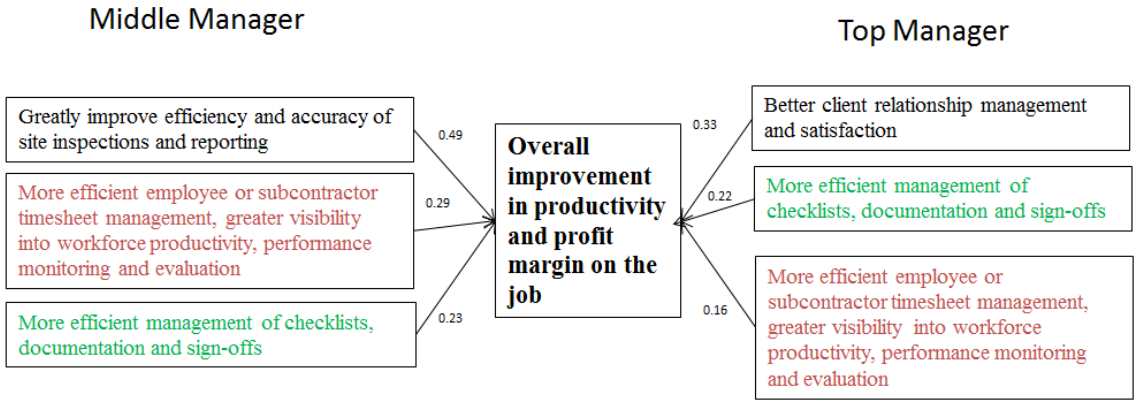

Figure 4. Comparisons between top and middle manager's view based on structural equation model

8.2 Perceived barriers of app use

We also asked top management and middle management to rate the barriers they perceive in the uptake of mobile technologies in the construction industry. Feedback from the in-depth interviews conducted during stage one helped in identifying a list of barriers in use of apps in the construction industry. Survey respondents ranked the list on a 5 point Likert scale marked from 1 (i.e. 'strongly disagree') to 5 (i.e. 'strongly agree'). The analysed results are shown in Table 5. All the p values are > 0.05, thereby indicating that there is no significant difference in perceived barriers between the top manager and middle manager. Table 5 further reveals that both top and middle managers consider 'general industry attitude and reluctance to change' to be the topmost barrier. This is followed by 'No time to learn' and 'apps and licensing fees are too expensive' from top managers' views; while "mobile devices are too expensive to buy or fix", "apps and licensing fees are too expensive" and "security concerns" from middle managers' views.

Table 5: Two-Sample T-Test Results of Barriers

Barriers	Top Manager (mean)	Middle Manager (mean)	P
No time to learn	3.386	3.179	0.263
No need to learn	2.509	2.513	0.983
Too difficult to learn	2.800	2.684	0.561
Mobile devices are too expensive to buy or fix	3.035	3.282	0.195

Apps and licensing fees are too expensive	3.351	3.282	0.699
Training is too expensive	3.088	3.154	0.719
Security concerns (safety of classified data)	3.158	3.282	0.506
General industry attitude and reluctance to change	3.386	3.538	0.426

The weighted mean for "too difficult to learn" and "no need to learn" from both top and middle managers were below the averaging rating point of 3, which means that both top and middle managers perceived that there is need to learn and it is not too difficult to learn. These indicate a positive attitude towards the uptake of mobile apps. Next, after all rated value of the barriers were added together, then applied the Two-sample test (refer Table 6). The result shows that there is no significant difference between the top and middle managers views about perceived barriers towards uptake of mobile apps (since the p value is greater than 0.05). However, the middle managers think slightly more about the barriers than the top managers.

Table 6: Two-Sample T-Test Results of Total Barriers

Barriers on use of apps	**Top Manager (mean value)**	**Middle Manager (mean value)**	**P**
Total Barriers	24.19	24.85	0.487

9. CONCLUSIONS

This research has investigated perceived benefits and barriers of uptake mobile apps from the top and middle management's point of view in New Zealand construction industry context. These are the people who make strategic, operational and tactical decisions to improve the workforce productivity.

We find a positive attitude towards use of apps to improve productivity by the senior management, more so by the middle managers than the top managers. The top managers think that the benefit of client relationship management and satisfaction has strongest relationship with overall productivity. While the middle managers are concerned more in automation of operational efforts like building inspections and reporting to help in improving their productivity. Apps can help them in performance monitoring and make overall evaluation more visible. Thus, apps can increase productivity by reducing the time spent on support functions at operational and tactical levels.

This study is not without limitations. The views expressed only from 137 construction professionals which is a small percentage of total construction professional workforce. Hence the view cannot be generalized beyond this study's scope. However, it provides a snapshot of the top and middle managers' attitude towards the uptake of mobile apps in the New Zealand construction sector. We intend to investigate next about which aspects of apps affects the usage behaviour of construction worker. Currently, there is limited research which looks at construction workforce's usage in mobile computing devices. It provides value to both policy makers regarding productivity measures from apps use and to software developers on preferred functionality while designing apps. The next phase of this study will help us get a better understanding on app acceptance and rejection behaviour from an individual point of view.

References:

Arditi, D. 1985. Construction productivity improvement. Journal of Construction Engineering and Management, 111, 1-14.

Azhar, S. & Cox, A. J. Impact of Mobile Tools and Technologies on Jobsite Operations. 51st ASC Annual International Conference Proceedings, Published by the Associated Schools of Construction, 2015.

Beatham, S., Anumba, C., Thorpe, T. & Hedges, I. 2004. KPIs: a critical appraisal of their use in construction. *Benchmarking: An International Journal,* 11**,** 93-117.

Bedard, P. 2013. *How Mobile Technologies are Boosting Construction Site Efficiency* [Online]. Halcyon Business Publications, Inc. Available: http://www.areadevelopment.com/AssetManagement/April2013/construction-site-mobile-project-management-272725.shtml.

Bowden, S., Dorr, A., Thorpe, A., Anumba, C. & Gooding, P. 2005. Making the case for mobile IT in construction. *Computing in Civil Engineering (2005).*

Bowden, S., Dorr, A., Thorpe, T. & Anumba, C. 2006. Mobile ICT support for construction process improvement. *Automation in construction,* 15**,** 664-676.

Bryman, A. & Bell, E. 2015. *Business research methods*, Oxford University Press, USA.

Caenz 2008. NZ Construction Industry KPI's. Author,. Available: http://www.constructing.co.nz/uploads/events/24/CCG%20June%2008%20presentation%20CAENZ.pdf.

Careersnz. 2017. *Building and Construction Manager* [Online]. author,. Available: https://www.careers.govt.nz/jobs-database/construction-and-infrastructure/construction/building-and-construction-manager/ 2017].

Conway, P. & Meehan, L. 2013. Productivity by the numbers: The New Zealand experience. Available: http://www.productivity.govt.nz/sites/default/files/Commission%20Research%20Paper%20-%20Conway%20Meehan%20Productivity%20by%20the%20Numbers%20-%20Productivity%20by%20the%20numbers%20%28final%29.pdf.

Davis, N. 2007. *Construction sector productivity*, Martin Jenkins.

Gajendran, T. & Perera, S. 2017. The Australian Construction e-Business Review.

Ikediashi, D. I., Ogwueleka, A. C. & Haupt, T. 2016. Assessing the use of ICT systems and their impact on construction project performance in the Nigerian construction industry. *Journal of Engineering, Design and Technology,* 14.

Kenley, R. 2014. Productivity improvement in the construction process. Taylor & Francis.

Lingard, H. 2013. Occupational health and safety in the construction industry. *Construction management and economics,* 31**,** 505-514.

Liu, T., Mathrani, A. & Mbachu, J. Hunting the Popular Construction Apps. Computer Science and Engineering (APWC on CSE), 2016 3rd Asia-Pacific World Congress on, 2016. IEEE, 205-211.

Ministry of Business Innovation & Employment. 2015. *Construction in New Zealand*. Available: http://www.business.govt.nz/worksafe/research/health-and-safety-data/pdf-and-documents-library/construction-sector-by-numbers.pdf [Accessed May 14, 2016].

Mintzberg, H. 1979. *The structuring of organizations*, Prentice hall Englewood Cliffs, NJ.

Page, I. & Norman, D. 2014. *Measuring construction industry productivity and performance*.
Pb Tech. 2017. *Google Pixel Smartphone 128GB Very Silver* [Online]. Available: https://www.pbtech.co.nz/product/MPHGOG0501281I/Google-Pixel-Smartphone-128GB-Very-Silver?qr=pspy&ref=pricespy.
Pricespy. 2017. *Apple iPhone 7 128GB* [Online]. Available: https://pricespy.co.nz/product.php?p=3895091.
Sattineni, A. & Schmidt, T. 2015. Implementation of mobile devices on jobsites in the construction industry. *Procedia Engineering,* 123**,** 488-495.
Seek. 2017. *construction manager* [Online]. Available: https://www.seek.co.nz/manager-jobs-in-construction/management 2017].
Sharma, A. & Gupta, D. 2014. Smartphone as a real-time and participatory data collection tool for civil engineers. *Int. J. Mod. Comput. Sci,* 2**,** 22-27.
Silverio, M., Renukappa, S., Suresh, S. & Donastorg, A. 2017. Mobile Computing in the Construction Industry: Main Challenges and Solutions. *Leadership, Innovation and Entrepreneurship as Driving Forces of the Global Economy.* Springer.
Slack, N. & Lewis, M. 2005. *Operations management*, Psychology Press.
Statista. 2017. *Number of apps available in leading app stores as of March 2017* Available: https://www.statista.com/statistics/276623/number-of-apps-available-in-leading-app-stores/ [Accessed June 14, 2017].
Susanne Balslev Nielsen, Anna-Liisa Sarasoja, Kirsten Ramskov Galamba, (2016) "Sustainability in facilities management: an overview of current research", Facilities, Vol. 34 Issue: 9/10, pp.535-563, https://doi.org/10.1108/F-07-2014-0060
Tangen, S. 2005. Demystifying productivity and performance. International Journal of Productivity and performance management, 54, 34-46.
Top Apps. 2013. Top Android Apps for Construction Industry [Online]. Author. Available: http://www.topapps.net/android/top-android-apps-for-construction-industry.html/ [Accessed May 14 2016].
Yovino, J. 2013. 13 construction apps for 2013 [Online]. Available: http://dailyreporter.com/2012/12/28/13-construction-apps-for-2013/ [Accessed October 10 2016].
Yi, W. and Chan, A.P.C. (2014) Critical review of labor productivity research in construction journals. Journal of Man-agement in Engineering, 30(2), 214–25.
Zikmund, W. G., Babin, B. J., Carr, J. C. & Griffin, M. 2013. Business research methods, Cengage Learning.