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Effect of human resources management and advances to improve construction project performance

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A B S T R A C T

The existence of a professional construction management agency has already accepted in the construction business in Indonesia. The outcome of the services has expected to improve overall project success. In the aim to obtain a more comprehensive figure of performances both from a financial and non-financial point of view, the PMBOK knowledge area is proposed to be tailored into a balanced scorecard based performance measurement. The foundation of the strategic map is 'learning or growth' perspective, where improvement is necessary to increase the organization's internal 'business process' perspective. Review of existing literature shows that construction project team's achievement generally measured by scope, cost, schedule, and quality performance, initially contributed by human resource management and advances. As the result of the study, human resource management shall comprise of competence, the role of project manager, recognition and reward, facility, and lesson learned. Advances shall include technology, building information modeling, modern method of construction, and emerging management technique. Furthermore, analysis of the relations between those elements is important for the agency's scoreboard model development.

1. Introduction

Data from the Centre of Statistical Bureau and Ministry of Public Works shows that the construction sector becomes the third contributor to Indonesian economic growth with a 0.56% portion from total 5.02% and as the fourth contributor to GNP with 10.38% portion. Such contribution is also a result of the high consumption of the national budget, which many parties have concerns regarding the efficiency of the expenditures. As the majority of the construction companies in all over the world face many obstacles, such as "workmanship defects', delay, and cost overrun issues in complementing their projects (Neyestani and Juanzon, 2016), the local government continue making efforts to minimize the construction failure by improving quality of *project management* as one of the important indicators.

Construction project management can be performed by every parties involved in a construction project such as the owner's organization or contractors, including engineering contractors (agency). As a case study of a private consulting engineers company, which provides construction management services, there is an opinion of top management that failure of a project (services) will create an unsatisfied customer and eventually give effect to corporate financial growth. An annual report shows that between the years of 2015–2019 the company had achieved 5% revenue growth instead of 10% as targeted. An internal survey to top management (n = 7) shows they believed that the performance of project organizations will affect sales growth, profitability and liquidity with average score 4.57 of 1–5 Likert scale (Table 1), consistent with the model of project success level (Camilleri, 2016). By separating external (in respect to market) issues, and since the company uses a balanced scorecard as a tool for performance measurement, they decide to improve the foundation of their strategy that is 'learning and growth' perspective (Fig. 1). Quality of the company's internal process needs improvement to gain the expected 'services performance'. The focus of a project plan is usually on a particular product, service, or program that will support the higher-level strategic plan (Saladis and Kerzner, 2009) and the performance of the project organization will support the company's performance. Furthermore, the performance of the agency's services on the project subsequently will support the owner's project performance.

There are numerous challenges to implement an improvement strategy. The use of a proper performance measurement system (PMS) in the organization has expected to promote 'total quality management" system as a management tool. In fact, the majority of managers consider only financial indicators to assess their organizational performance and lack of knowledge concerning systematic performance indicators (Neyestani and Juanzon, 2016). Obviously, the use of a holistic and representative organization construct, which is performance, is useful. Once organizations form their set up, either in corporations or projects, regardless of the organization's type, they collect and arrange the

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Table 1
Result of preliminary survey to top management (n = 7).

	Factors	Score[a]
Influence of project organization's performance to the company's performance	Revenue Growth	4.86
	Profitability	4.57
	Liquidity	4.43
	Customer Satisfaction	4.43
Influence of human resources performance to project organization's performance	Schedule	4.29
	Quality	4.43
	Cost	4.00
	Administrative	4.29

Note.
[a] Average score of influence rate using 1–5 Likert scale.

required resources necessary to run their activities and thereby achieving their goals and targets. It is important to measure how well the resources managed and how best the organizations run their activities (Goshu and Kitaw, 2017).

Balanced scorecard concept as one of the performance measurement methods recently used in many organizations in the country. Because it is not a template that can be applied to businesses in general or even industry-wide, research should be undertaken in each organization to customize their process. Different scorecards required for different market situations, product strategies, and competitive environments while business units customized their scorecards following their mission, strategy, technology and culture (Wadugodapitiya et al., 2010). The company has been used the strategic map as shown at the above Fig. 1 for the last decade. Initially the strategic objective generated from SWOT analysis using a brainstorming method supported by interviews. To anticipate the expected growth (gap) as previously described, top management has decided to add advancement in construction technology as another strategic objective within 'learn and growth' perspective, following the popular megatrend 2020. It is been said that the fourth industrial revolution is transforming the economic paradigm and mechanisms used to create value and generate benefits, i.e., efficiency, effectiveness, and customization, as well as quality and innovative product, projects, and services (Berawi, 2018).

However, such a decision required a further reliable approach considering the needed investment. Research is necessary to understand relations among variables, which are human resources management and advancements in construction technology against the performance of the CM services.

The purpose of this study is to identify what indicators relevant to the issues.

For further research, a model of the constructs can simply describe as Fig. 2 below.

Research questions arise from the above figure are: 1) what kind of technology required and what indicators shall be used to explain the latent variable such as human resources management relevant to the CM agency services performance's manifest? 2) how will human resources management influencing such performance? and 3) in what way shall the advancement in construction technology affecting the construction management agency's services performance?

2. Literature review

2.1. Performance of CM agency

According to Indonesian law on construction services, construction failure defined as circumstances when the Work result are not on conformance to specification as agreed on the Contract either partially or as a whole due to employer's or services provider's misconduct (UUJK, 2017). Government regulations stated that construction failure is a situation of construction disability to be functioned, either all or parts from technical, usage, health and safety, fund and or public safety aspects, due to employer's and/or services provider's misconduct after final hand over of the Work (PPRI, 2000). Circular letter from Ministry of Public Work issued following regulations of the same regarding technical guidance of state building construction stated that construction management consultant should manage/supervise the work by

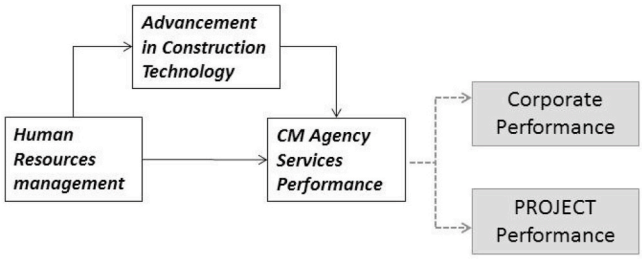

Fig. 2. Relations between concerned issues.

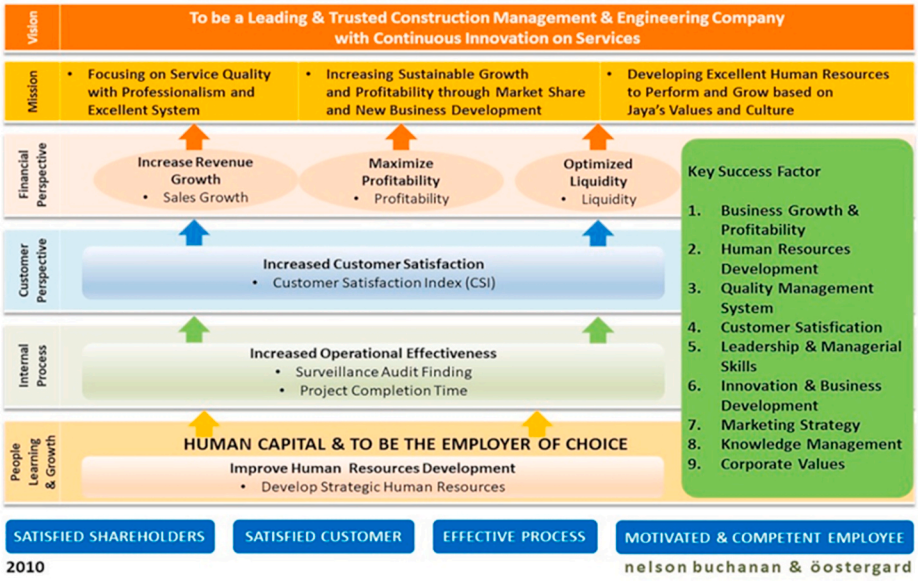

Fig. 1. Strategic map of a consulting engineers performance based company.

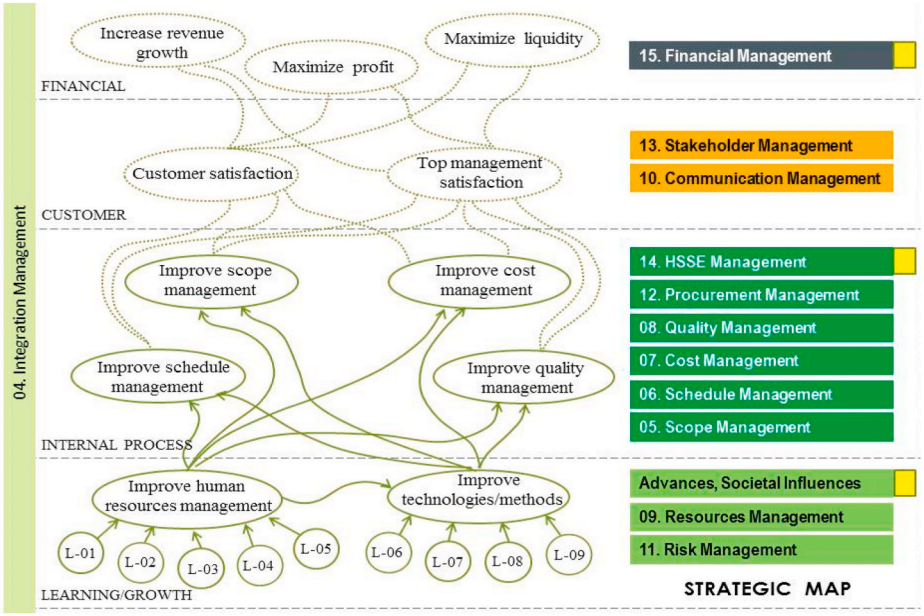

Fig. 3. Knowledge areas in strategic map (adapted from Truong, 2008).

design consultants and contractors involved in the reference unit in the aspects of *quality, time, cost, and contract administration* (SEPUPR, 2010).

An owner's guide to project delivery methods issued by CMAA stated that Construction Management is a discipline uniquely tailored to the planning, design, and construction process of capital projects. *Agency Construction Management* is a management process whereby the owner utilizes a construction manager (CM) as its principal agent to advise on or manage the process over the life of the project, or during specific phases of the project. Construction Management accepted as a professional management practice fit to construction projects from the initiation phase to completion for the purposes of controlling *time, cost, scope and quality* (CMAA, 2012). Two forms of construction management that are agency CM and CM-at-risk. In the agency CM type of management system, the client has three contracts, one between the owner and the designer, one between the owner and the contractor, and one between the owner and the CM. In the CM-at-risk type of project delivery system, the client has two contracts, one between the owner and the designer and one between the owner and the CM-at-risk/general contractor (Rumane, 2016).

Basic services of construction management refer to the CMAA standard form of agreement between owner and CM for CM agency (CMAA, 2005) and CM-at-risk (CMAA, 2004) relatively the same as CM scope according to Ministry of Public Works (SEPUPR, 2010). They are both have services along with the pre-design phase, design phase, procurement phase, and construction phase, except that the CMAA standard form has more details on the post-construction phase. CMAA standard also has more details on project management and management information system (MIS) along with phases, but less detail on quality management, where the term of reference issued by the Ministry of Public Work has emphasized.

2.2. PMI PMBOK® guide

Despite the difference between project management and construction management system in terms of project delivery system (Rumane, 2016), they are both have similar characteristics of knowledge areas. While PMBOK for CM (Construction Extension) has 12 knowledge areas, preliminary main structure of CMBOK recently proposed (Chen, 2019) has 18 knowledge areas of cognitive domains, with distinction to workforce group (people) and production group consists of design, engineering, facilities, and plant management.

Some of the knowledge areas of Construction Extension to the PMBOK® Guide considered inline with performance. As understood that the performance of project organizations contributes to the company's performance, then the strategic management should have a relationship with project management. When we superimposed the performances into a strategic map based on BSC, it becomes a framework shown in Fig. 3. With strategic performance measurement, an organization may avoid serious difficulties in managing its strategy because of a lack of actual data for comparison with organizational objectives (Truong, 2008). On further development of this study unto research, it may have resulted as an importance-performance rank of indicators and sub-indicators which necessary to form the performance measurement formula, besides the purpose of an investment priority.

2.2.1. Human resources management

Resources, in general, form the biggest part of the cost in any construction project productivity and greatly influence project time and cost (Ifediora and Keke, 2019). One of the research shows the difference in the productivity of both workmen and equipment is to the tune of 70%–80% of the standard productivity. The lack of productivity related to; unavailability of clear work front, no proper planning, the skill of the worker, and no proper supervision (Venkatesh and Natarajan, 2018). Apart from general resources, human resources may be a construction organization's most valuable asset and a key factor for business success (PMI, 2016). As a view of important factors, based on the result from one of the surveys for a real estate project showed that among human resources practices, supervision/checks/inspections and hiring/-recruitment/staffing ranked first (Ifediora and Keke, 2019).

Construction Extension to the PMBOK® Guide suggested classified resources into two main aspects that are general resources and human resources. Human resources itself should be discussed in different manner concerning labour and staff. While the Guide provides the general foundation for managing projects, the *construction extension* addresses the specific practices found in construction projects (PMI, 2016). It described more principles or policies than the workflow of processes. While keeping the same form of process group as planning, executing, monitoring and controlling, the *extension* also adds the closing process into the Section. The principles of human resources management can be seen in Table 2 below.

The most important critical success factors (CFSs) within the project life cycle, include internal team capability and external matters are

Table 2
Project human resources management according to construction extension to PMBOK® guide 2016

Policies	Process Flow
	PLANNING
Strategy, processes and performance indicators	Incentives or restrictions for team members to move to the region of the project, Schedule of periodic visits to the members home location, time off, and trip cost, Currency in salaries and taxes, Site campus condition, Site personnel fringe benefits.
	EXECUTING
Important points to consider	Staffing, Team Building, Interpersonal Skill
	MONITORING AND CONTROLLING
Allocation and reallocation	Productivity and consumptions rate, Turnover rate
	CLOSING
Dissolution of team member	Demobilization, reassignment, Extracting good practices and lessons learned.

Table 3
Advances in construction project management according to construction extension to PMBOK® guide 2016

Advances	Topics
Technology	Machines equipped with geospatial positioning, sensing, and measurement, Sensors to monitor and measure deformation and predict failure, Centralized web-based and cloud-based construction document management system, Construction collaboration technologies (CCT) software, Mobile technology, 3-D printing technology, Unmanned aerial vehicles equipped with HD cameras, Streaming digital video Sophisticated software animation
Building Information System (BIM)	Improving how project designed and built, Distribution of information to all stakeholders, Provide the means to construct complete virtual prototypes.
The modern method of construction	Prefabrication, Modularization facilities.
Emerging management techniques	Alternative project delivery method (IPD approach): design built, PPPs, multinational joint ventures, Lean and agile management approaches.

project mission, top management support, competence of project manager, project schedule/plan, client consultation, the competence of project team members, technical tasks, client acceptance, monitoring and feedback, communication, and troubleshooting (Babu and Sudhakar, 2015).

Developed form the above literature and Table 2 in particular, indicators for human resources management can be set up as competence; the role of the project manager; recognition and rewards; facilities; and lessons learned.

2.2.2. *Advances*

The leading factors in the slow uptake of technology advances seem to be twofold. The first factor is the general reluctant to adapt within the industry at large, and the second appears to be the cost of the new technology. However, as all parties in the construction industry continue to recruit younger staff who are more familiar with technology, it is likely that this resistance will cease (Navigant, 2016). Apparently, relations between human resources and advances rely on common practices by younger generations, despite the pressure of competition and the extensive complexity grown on construction environment.

Basic services of the construction management system along the project phases according to CMAA are project management, time management, cost management, and management information system (MIS). As the control mechanism in mitigating design changes and rework in building construction projects, it is suggested that effective communication leads to collaboration and the cohesive team which encourages dynamic involvement in management decision making (Hui et al., 2017). Within the resource management knowledge area of PMBOK-ITTOs, communication technology becomes one of tools and technique in develop team process group, while project management information system becomes tool and technique in manage team process groups (PMI, 2017).

Beside introduces the practitioner to the knowledge areas and process groups, Section 3 of *construction extension* offers an overview of advances in technology and management techniques promoting project management to become unique in the construction environment (PMI, 2016). The summary of the advancement is shown in Table 3 below, where each topic may be considered as factors for the variables in further research.

Task managers need to utilize equipment suitable for facing various demanding situations. Therefore, initiatives managers firstly shall continue to conflict with the issues. At the same time, secondly they are obliged to make choices in one of these manners that chances are managed, uncertainty reduced and in which every equipment selection made will ideally be beneficial to the challenge. The project management systems currently used may be devised into two kinds, off-the-shelf commercial software program and custom-in-residence software program (Bor and Kiptum, 2017). Leading commercial software companies keep proposing solutions for construction project control automation program. To facilitate users with planning and monitoring of construction works automation, management of documents as well as information sharing on project status, several BIM-based construction management platforms and mobile filed applications assembled (Ratajczak et al., 2019).

Prefabrication and modularization, as a modern method of construction, are not new activities to construction professionals; however, they are becoming more prevalent as key drivers to improve construction industry productivity through greater efficiencies (Venkatesh and Natarajan, 2018). Construction projects often suffered by delay and off-budget and rework become a requirement to satisfy customer's needs. Lean construction is a project management philosophy based on a set of approaches developed in production management and adapted for project management. Lean thinking in construction can be summarized in: waste elimination; improving reliability; creating continuous flow in a pull system; meet the customer's need; involvement of workers in every level; involvement of supplier and client in the project process; built-in quality; continuous improvement knowledge sharing (Locatelli et al., 2013).

3. Research methods

Various organizations in the country use PMBOK as a reference for executing their projects. Founded in 1996, PMI of Indonesia is dedicated to improving, consolidating, and channelling Indonesian PM's knowledge and expertise for the benefit of all project stakeholders. However, the implementation of the standard guidelines for PMBOK is still not optimal (Chou and Pham, 2013). This study offers to merge knowledge areas in the guidelines into a strategic performance measurement model, in which process groups can be elaborated within perspectives. It is widely accepted that strategy involves performance to attain goals. However, goals without performance measures do not motivate managers (Truong, 2008).

The introduction of this study limited to a construction management company's background. With the intention to obtain a complimentary

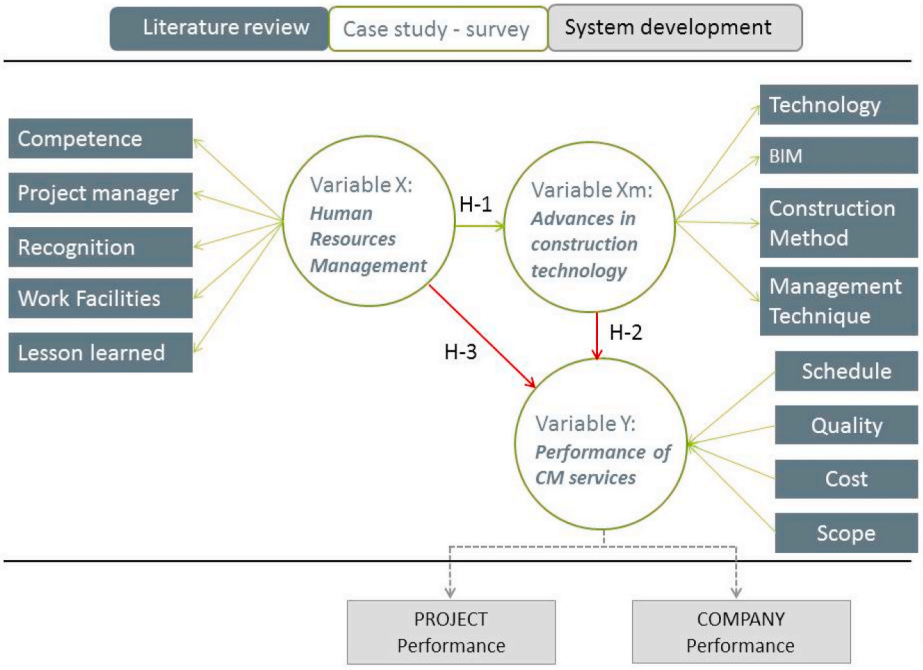

Fig. 4. Framework and model for further research.

review, the research shall be undertaken involving internal or external experts and practitioners. Proposed hypothetic relations between the performance of construction management services with human resource management and advances are:

H-1. advances are mediators between human resources management and performance,

H-2. improvement on advances will give positive effect to performance, and

H-3. improvement in human resources management will give a positive effect on performance

. Following the above review, framework and model for further research shown in Fig. 4. The result of the study will be used as measure for strategic management and a framework for team development.

The previous literature review has identified sub variables and their indicators necessary to answer RQ1. In order to obtain responses regarding RQ2 and RQ3, a case study has chosen. Limitations have been made for the research i.e. 1) data will be gathered only from single corporation, 2) a case study shall be conducted to collect only team leader's opinion in respect of the issues.

Survey instrument shall be arranged with basic question that is how strong will the agency's services performance affected by the indicators. Participants shall show their opinion in between the 1–5 Likert scale for each question. There will be 84 questions prepared from the first literature review, and every answer required to be repeated for four times to cover scope, schedule, cost, and quality aspect of performance. Population of 75 respondents from the internal CM agency divided into team leader, engineering group leader and site management's group leader. The data from these groups are to be test through multivariate check prior to the PLS-SEM analysis, which includes chi-square, H-test and Z-test ($p > 0.05$). A model of relation between variable will be created with the assistance of *SmartPLS* software and continue with reliability, validity and other goodness of fit check.

4. Data and model review

Expert's validation process through interviews and Delphi Technique produced a firm survey instrument has to be distributed to all

Table 4
Codes for relation between variables modeling.

Codes	Variables
PFORM	Performances of CM Agency
CMP	Competence
PMR	Project Manager's Role
RWD	Recognition and Reward
FCL	Work Facility
KM	Dissolution of Team Members
ICT	New Technology
BIM	Building Information Modeling
CMT	Prefabrication and Modularization
MMT	Emerging Management Techniques

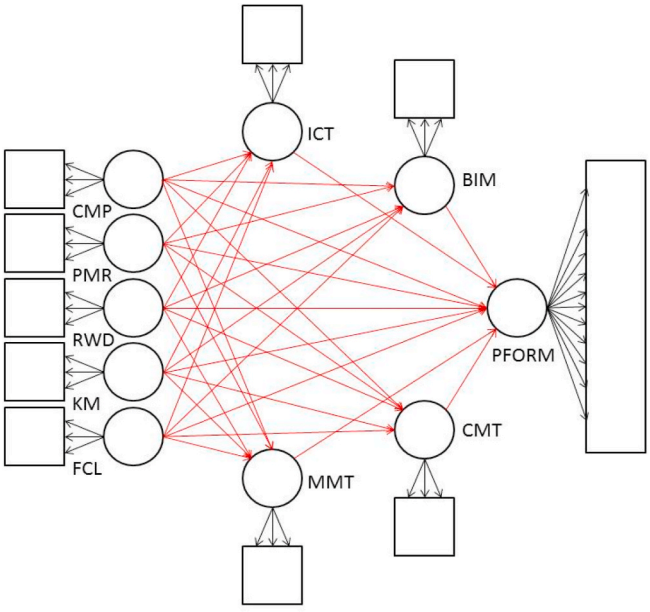

Fig. 5. Model of relation between variables.

Table 5
Indicators for performance after reliability iteration.

VAR	Indicator	PERFORMANCE							
		SCOPE		SCHEDULE		COST		QUALITY	
		Outer Loadings		Outer Loadings		Outer Loadings		Outer Loadings	
PFORM	Y1					0.845	✓		
	Y4	0.751	✓			0.784	✓		
	Y8	0.857	✓			0.811	✓		
	Y9	0.834	✓			0.819	✓		
	Y10					0.803	✓		
	Y11			0.759	✓	0.853	✓		
	Y12			0.748	✓	0.847	✓	0.755	✓
	Y13	0.807	✓	0.746	✓				
	Y15			0.837					
	Y17			0.748				0.706	✓
	Y19			0.797	✓	0.743	✓		
	Y23			0.879	✓			0.739	✓
	Y24			0.726	✓			0.764	✓
	Y25							0.788	✓
	Y26							0.764	✓
	Y27							0.763	✓

respondents. Selected questions confirmed with some to be eliminated during the process.

After the above basic statistical test, there are 65 indicators and 66 respondents remain for further analysis.

Human resources management eventually divided into 5 sub variables which are competence, project manager's role, reward and recognition, work facility, and dissolution of team members. Advancement in construction technology supported by 4 sub variables consist of new technology, Building Information Modeling (BIM), modern method of construction, and emerging management techniques. Performance, in particular, will be a single variable. Codes were made to represent sub variables for structural equation modeling as shown in Table 4.

As a development of the previous research model (Fig. 4), the above model (Fig. 5) shall refer to several studies conducted for each connecting line, where such studies are not all discussed in this brief report.

Modeling for H-2 and H-3 are relatively simple where each sub variable (became latent variable) directly connected to performance. The inner model became more complex when sub variables of technology are expected to be mediators (H-1). This assumption creates 5 times 4 new lines between sub variables in advances and human resources group. Although such consequences are not all supported by previous literature review, this case study will provide findings to be considered.

Types of statistical check used for this measurement model includes reliability and validity check. Path coefficient, total effect and path significance also tested to figure out the strength of relations. In addition, model fit and collinearity VIF check also used to confirm the

Table 6
Path coefficient.

VARIABLE		PERFORMANCE							
		SCOPE		SCHEDULE		COST		QUALITY	
Exogen	Endogen	Path Coefficient		Path Coefficient		Path Coefficient		Path Coefficient	
CMP	ICT	−0.093		0.100	✓	0.188	✓	0.058	
	BIM	−0.341		0.207	✓	0.079		0.204	✓
	CMT	0.000		0.272	✓	0.127	✓	0.195	✓
	MMT	0.001		0.591	✓	−0.010		0.223	✓
	PFORM	−0.188		0.191	✓	−0.019		0.134	✓
PMR	ICT	0.130	✓	0.023		0.119		0.056	
	BIM	0.407	✓	0.279	✓	0.275	✓	0.470	✓
	CMT	0.372	✓	0.108	✓	0.223	✓	0.236	✓
	MMT	0.509	✓	0.029		0.179	✓	0.210	✓
	PFORM	0.275	✓	0.316	✓	0.151	✓	0.088	
RWD	ICT	0.152	✓	−0.006		0.028		−0.025	
	BIM	0.349	✓	−0.196		−0.120		−0.058	
	CMT	0.155	✓	−0.083		0.079		−0.202	
	MMT	0.253	✓	−0.002		0.093		0.079	
	PFORM	0.183	✓	0.022		0.051		0.216	✓
FCL	ICT	0.193	✓	0.276	✓	0.430	✓	0.364	✓
	BIM	0.235	✓	0.166	✓	0.462	✓	0.286	✓
	CMT	0.269	✓	0.005		0.260	✓	0.410	✓
	MMT	0.100	✓	0.091					
	PFORM	0.224	✓	0.022		0.220	✓	−0.042	
KM	ICT	0.361	✓	0.382	✓	−0.018		0.293	✓
	BIM	−0.025		0.354	✓	0.280	✓	0.121	✓
	CMT	0.234	✓	0.222	✓	0.097		0.047	
	MMT	0.145	✓	−0.068		0.222	✓	−0.118	
	PFORM	−0.032		0.030		0.020		0.115	✓
ICT	PFORM	−0.073		0.271	✓	0.011		0.310	✓
BIM		0.428	✓	0.145	✓	0.074		0.050	
CMT		−0.341		−0.068		−0.032		0.168	✓
MMT		0.295		0.198	✓	0.680	✓	0.216	✓

Table 7
Total effect.

VARIABLE		PERFORMANCE							
		SCOPE		SCHEDULE		COST		QUALITY	
Exogenous	Endogenous	Path Coefficient		Path Coefficient		Path Coefficient		Path Coefficient	
CMP	PFORM	−0.327		0.347	✓	−0.022		0.244	✓
PMR		0.463	✓	0.361	✓	0.286	✓	0.214	✓
RWD		0.343	✓	−0.003		0.103	✓	0.154	✓
FCL		0.249	✓	0.139		0.251	✓	0.189	✓
KM		−0.106		0.156	✓	0.189	✓	0.194	✓

Table 8
Path significance in bootstrapping.

VARIABLE	PERFORMANCE							
	SCOPE		SCHEDULE		COST		QUALITY	
	T Statistics		T Statistics		T Statistics		T Statistics	
CMP - > BIM	2.466	supported	1.986	supported	0.924		2.056	supported
CMP - > CMT	0.003		1.959		0.779		1.573	
CMP - > ICT	0.572		0.837		1.247		0.477	
CMP - > MMT	0.011		4.645	supported	0.074		1.484	
CMP - > PFORM	1.276		1.478		0.290		1.287	
PMR - > BIM	3.074	supported	2.169	supported	1.439		1.709	
PMR - > CMT	2.667	supported	0.699		0.726		0.410	
PMR - > ICT	0.700		0.164		1.308		1.483	
PMR - > MMT	4.331	supported	0.192		1.908		0.568	
PMR - > PFORM	1.605		2.924	supported	0.928		0.462	
RWD - > BIM	2.141	supported	1.548		0.489		1.348	
RWD - > CMT	1.154		0.437		0.189		0.180	
RWD - > ICT	1.119		0.043		0.721		0.651	
RWD - > MMT	2.317	supported	0.013		0.564		1.465	
RWD - > PFORM	1.179		0.179		0.599		0.249	
FCL - > BIM	0.125		1.286		3.953	supported	1.974	supported
FCL - > CMT	1.671		0.035		1.413		3.191	supported
FCL - > ICT	2.643	supported	1.806		2.368	supported	2.061	supported
FCL - > MMT	0.951		0.720		2.263	supported	0.238	
FCL - > PFORM	0.182		0.177		0.116		2.793	supported
KM - > BIM	1.628		2.403	supported	0.668		0.275	
KM - > CMT	1.900		1.098		0.108		1.769	
KM - > ICT	1.439		1.918		1.588		0.675	
KM - > MMT	0.758		0.426		0.233		0.701	
KM - > PFORM	1.409		0.187		9.017	supported	2.617	supported
ICT - > PFORM	0.408		2.387	supported	2.622	supported	0.716	
BIM - > PFORM	1.631		0.972		0.599		0.249	
CMT - > PFORM	1.618		0.535		0.349		1.646	
MMT - > PFORM	1.448		1.787		2.379	supported	4.302	supported

model's goodness of fit.

5. Results and discussion

Numbers of indicators selected after iterations for outer loadings are 13 for human resources management, 32 for technology. Mostly they appear in scope aspect, while for schedule, cost, and quality aspects, less numbers of indicators considered. On the contrary, while there are 16 indicators stand for performance, all of them shared in more or less the same numbers for the three aspects, and the scope aspect has less number than the other (see Table 5).

Later on, after structural path significance hypothetical test in bootstrapping, the number of indicators in the outer models are remain the same.

As displayed in Fig. 3, performance has positioned in the internal business process perspective, above the learning or growth perspective. This means that all indicators of human resources and technology shall contribute either to each or at once towards the scope, schedule, cost, and quality aspect of performance.

Limitation concerning the strength of an effect between variables is 0.1, which means that the higher value above it shall show the more significant the influence of each variable to the other ones. As a result of the research, path significance of the inner model are shown in Table 6 below.

After some trial by adding moderators into the model, there is no moderating effect found as a result. However, while the effect of intervening variables cannot be seen in the above tables, mediation role of some variables can be described by their total effect (see Table 7).

Significance of a model shall be tested using T-test with significance level 10% (two tail). Ho (neutral) stated that there is no relation between variables and on the other hypothesis there is relation between variables (Ha). The t value resulting by calculation will be compared to value from T-table (for dF = 64 then t = 1,67). Path significance in bootstrapping can be seen in Table 8 below.

The above table shows that not all connections are supported, and even if there is a relation between independent variable to performance, it only supported in some aspects. In human resources group, competence (CMP) doesn't have a direct effect to performance as well as reward and recognition (RWD). In advances group, only effect of ICT and emerging management techniques towards performance are supported. However, some value can be considered with note, by increasing level of significance in reasonable manner. The other way to keep utilize some variables is by examine the mediation path from human resources unto performance through technology.

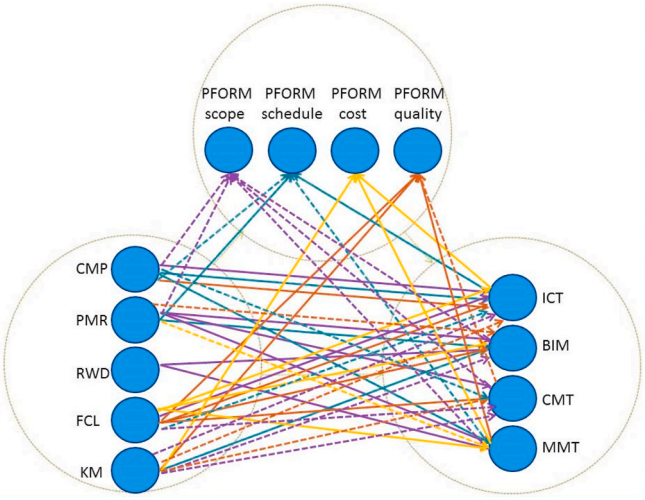

Fig. 6. Relations in inner model.

Result of such exercise can be summarized in Fig. 6.

Straight lines show direct effect, while dotted lines show potential effect by lowering the confidence interval. Purple line shows connections for scope aspect of performance. Green line shows connections for schedule aspect, yellow line for cost, and red line for quality aspect of performance. The bigger circles show main variables while smaller circles show sub variables.

6. Conclusion

Responses to the research questions can summarized as:

RQ1. Technology required and indicators used to explain the latent variable such as human resources management relevant to the CM agency services performance's manifest have described by literature review. The main reference used is Construction Extension to the PMBOK Guide 2016 and The PMBOK Guide 2017.

RQ2. Human resources management has influencing performance mainly by, project manager's role, work facilities, and dissolution of team member. Competence of the work force and the recognition and reward will considered to give effect with the assistance of technology.

RQ3. The advancement in construction technology affecting the construction management agency's services performance mainly by new technology/ICT and emerging management techniques, while Building Information Modeling and new construction methodology potentially remain to be considered.

In general, advancement in technology became mediator between human resources and performance (H-1 accepted). Improvement on advances gives positive effect to performance (H-2 accepted) and improvement of human resources management gives positive effect on performance.

7. Recommendations

After found out understandings of the characteristic of relations between variables in the case study, as one of the purpose of the study, selection is required to form key indicators for performance measurement. A scoreboard developed by using path significance to arrange order of the indicator, and the outer model use to assist the performance's formula statement establishment.

Further research proposed to continue to include all other perspectives of the strategic plan, in the way that performance of the services will give effect to customer satisfaction and financial perspective.

As the case study implied only to a specific corporation, scale for the research may need to be enlarged for further study.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pce.2021.103000.

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