Framework for Identification of Factors Affecting Construction Crew Motivation and Performance

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Abstract

Construction researchers have long had difficulties identifying motivational factors and situational/contextual factors affecting crew motivation and performance. The two main objectives of this paper are to define a methodology to identify the factors affecting construction crew motivation and performance, and to bridge the gap in construction research by exploring more recent motivational concepts that have been introduced and advanced in non-construction domains. This paper presents a general review on motivation literature, applies recent advancements in motivation research from non-construction disciplines, and presents a case study to illustrate the proposed methodology and findings from data analysis. This paper makes three contributions: first, it provides a comprehensive set of factors affecting crew motivation and performance; second, it presents a novel methodology for identifying and measuring motivational factors at both the individual and crew levels; and third, it defines a methodology to evaluate and rank critical factors and factors with a high potential for improvement in construction crew motivation and performance and to evaluate the differences between the perspectives of supervisors and craftspeople on the identified critical factors.

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Introduction

Labor is a critical resource in construction, and being able to effectively predict and improve crew motivation and performance is an important factor in achieving project success. However, predicting crew motivation and performance involves many challenges in areas such as determining the attributes of crew performance (e.g., productivity), and identifying the factors affecting crew performance. Campbell (1990) defines motivation as "the extent to which persistent effort is directed toward a goal". Generally speaking, workplace motivation is defined as the direction of attention, mobilization of effort, and persistence of effort over time, exhibited by individual employees and aggregated across individuals within a work group (Latham and Pinder 2005). Individual and group performance has long been viewed as a function of both capability and motivation (Campbell 1990). Therefore, when studying crew performance, it is important to consider not only situational/contextual factors (i.e., the factors related to the situation in which the tasks are performed) but motivational factors as well.

In construction, workers complete tasks in crews, which means that crew performance is a function of workers' interactions with each other and with their environment, rather than just the performance of individual members. Therefore, in order to assess the performance of a crew, it is essential to assess the motivation of construction crews not only at the individual level but also at the crew level. Unfortunately, the construction literature has tended to overlook, assume, or de-emphasize motivational explanations when accounting for variations in labor productivity and performance (Maloney 1986; Maloney and McFillen 1987; Siriwardana and Ruwanpura 2012). To bridge the gaps in existing construction literature, this paper attempts to answer the following questions: What factors contribute to individual and crew motivation, and how are these factors identified and measured?

Though motivation is a major research focus in many disciplines such as business and psychology, limited research has been devoted to motivation in the construction context. For a review of the broader work-motivation literature, see Diefendorff and Chandler (2011). On the other hand, much of the literature that does exist in construction exhibits shortcomings. For example, most theories of motivation consider the motivation of an individual without taking into account the social context in which activities occur, which limits the conclusions that may be drawn (Raoufi and Fayek 2015). However, drawing upon non-construction literature must be done carefully, since the nature of construction work imposes constraints that may limit the relevance of well-established, individual-level motivational theories. Construction projects involve highly interdependent activities performed by crews, and performance in construction is multi-dimensional and is impacted by conditions outside of the scope of control of individuals. Therefore, in addition to the questions raised earlier, this paper examines the motivational factors can be reasonably assessed at both individual and crew levels in order to better capture the reality of construction crew dynamics.

The two main objectives of this paper are to define a methodology to identify the factors affecting construction crew motivation and performance, and to bridge the gap in construction research by exploring more recent motivational concepts that have been introduced and advanced in non-construction domains. This paper also aims to determine a methodology for identifying factors with a high potential for improvement in construction crew motivation and performance, as well as the factors for which there are statistically significant differences between the perspectives of supervisors and craftspeople.

This paper provides a review of current literature on motivation and applies the most recent advancements in motivation research from non-construction domains to the construction domain.

Following a discussion of the research methodology, this paper identifies the factors affecting construction crew motivation and performance. Next, the design of the interview surveys is explained, and the results of survey data analysis are presented. Finally, conclusions and avenues for future research are proposed.

Literature review of motivation in the construction domain

Early work on the topic of motivation within construction contexts has tended to focus on expectancy theory (Maloney 1986), a cognitive theory of motivation, which asserts that individuals will choose to engage in two primary types of activities: activities that they believe they can do well, and activities that will lead to valued outcomes. It became evident from the review of past studies that other motivational factors might be relevant for construction crews, such as the nature of the work, the characteristics and behaviors of the leader/supervisor, and the role of financial incentives (Maloney and McFillen 1987). Maloney and McFillen (1987) collected questionnaire responses from different trades to determine the impact of factors such as general effectiveness and openness on individual worker motivation; they concluded that planning, organizing, staffing, directing, and controlling of work crews would increase worker performance and satisfaction.

More recently, researchers have expanded their view of motivation in the construction context. Shoura and Singh (1999) used need theories to identify the motivational parameters of engineering managers. Goal setting, workforce needs, and workforce incentives/rewards were identified as factors that promote positive motivational behavior in construction subcontractor crews (Cox et al. 2006). Šajeva (2007) identified work, personal growth and continuous learning, autonomy and personal freedom, status and recognition, and monetary motivators as factors affecting the motivation and loyalty of knowledge workers. Management, supervisor's assessment, motivation based on expectancy theory, and technical skills were also identified as four categories of factors affecting productivity (Siriwardana and Ruwanpura 2012).

In summary, a review of current literature indicates that there are major shortcomings in motivation research for the construction domain. For example, some studies overlooked motivation at the crew level and largely relied on motivation at the individual level, some studies lacked data collection, and many studies based recommendations only on perceptions rather than data analysis. A major gap in construction research is in defining factors affecting crew motivation at both the individual and crew levels. To remedy these limitations, this paper provides a novel and comprehensive set of factors affecting crew motivation and performance, and identifies factors affecting motivation at both the individual and crew levels.

Literature review of motivation in the non-construction domains

Although numerous individual-level work-motivation concepts have been identified in the literature (Diefendorff and Chandler 2011), there are other possible motivational concepts that might influence crew motivation at both the individual and crew levels. An extensive review of literature outside the construction domain was conducted, and four motivational concepts have been shown to operate at both levels: efficacy (Bandura 1977; Hannah et al. 2016), commitment/engagement (Meyer and Allen 1991; Cesário and Chambel 2017), identification (Ashforth and Mael 1989; Lin et al. 2016), and cohesion (Beal et al. 2003; Chiniara and Bentein 2017). The following sections provide a discussion and review of research findings for each concept.

Efficacy

Efficacy has been shown to have a potent motivational impact on individuals (Bandura 1977). Self-efficacy (i.e., efficacy at the individual level) refers to an individual's judgment of his or her ability to execute courses of action required to attain a designated outcome (Bandura 1977). However, efficacy can also be experienced at a collective (i.e., group, team, or crew) level. Collective efficacy refers to shared beliefs within the group about the collective abilities of members to execute actions required to attain a designated outcome (Bandura 1977). In construction, self-efficacy entails an individual worker's judgments about his or her ability to perform a specific task, while collective efficacy refers to the crew's shared judgment of its ability to perform a specific task. Research on non-construction work teams suggests that efficacy, assessed at both the individual and group level, is positively associated with group-level performance outcomes (Gully et al. 2002; Hannah et al. 2016;Tasa et al. 2011).

Commitment/engagement

Commitment/engagement refers to an individual's emotional attachment to and involvement in the organization and/or to a course of action (Meyer and Allen 1991). These felt emotional bonds, such as emotional attachment to the organization, have been associated with various motivational states (Meyer et al. 2004; Johnson and Yang 2010). In additional to motivational states, emotion-based or desire-based commitment/engagement has been shown to have a positive relationship with technical task performance, a negative relationship with citizenship behavior/contextual performance, and a negative relationship with counterproductive behavior, absenteeism, and turnover across jobs and situations (Cesário and Chambel 2017; Gellatly et al. 2006; Meyer et al. 2004). Emotional contagion is the concept that a person's emotional responses trigger similar responses in other people (Hatfield et al. 1994). To the extent that commitment/engagement captures emotional content, it may be assumed that the logic underlying emotional contagion allows for the group-level conceptualization of commitment/engagement. For instance, a worker with low levels of commitment/engagement working in a crew of highly committed/engaged members will become more committed/engaged due to their interactions with highly committed/engaged crew members.

Identification

Identification has also been shown to impact motivation at both individual and group levels. Identification has been defined as "the emotional significance that members of a given group attach to their membership in the group" (Ashforth and Mael 1989; Lin et al. 2016; Van de Vegt and Bunderson 2005). In short, when attraction is high, members want to work together and are better equipped to communicate and coordinate with each other. In turn, these conditions should increase the crew's level of attention, effort, and persistence in regards to the ongoing task. Identification at the individual level is associated with the motivation of individuals to achieve collective goals, and it has been positively correlated with individual job performance. Identification at this level also increases an individual's self-esteem, elevating his or her performance. In contrast, identification at the group level generates positive evaluations of group potency (i.e., the group's collective belief in its ability to perform well), which elevates performance (Lee et al. 2011).

Cohesion

Cohesion has also been shown to impact motivation at the individual and group levels. Cohesion reflects the extent to which members want to remain in the group (Dobbins and Zaccaro 1986); it entails the extent to which the members of a group are attracted to one another, whether they feel a bond to one another, and/or whether members "stick together" as a unit. Cohesive work groups have been shown to be more productive than non-cohesive groups (Beal et al. 2003; Chiniara and Bentein 2017). Though cohesion can be assessed at both individual and crew levels, the relationship between cohesion and performance appears to be stronger when cohesion is considered at the group level (Gully et al. 2012). When assessed at the individual level, cohesion is related to an individual's level of attraction or sense of belonging to a group. When assessed at the group level, cohesion is related to mutual attraction among group members. The relationship of cohesion to performance is complex, as it is influenced by other factors (e.g., task type). For example, tasks that involve more interaction among group members increase the effect of group cohesion on performance (Beal et al. 2003).

Research Methodology and Paper Organization

This research began with the identification of factors affecting construction crew motivation and performance. The primary list of factors was derived from existing research in both construction and non-construction domains. First, a motivation expert with 30 years of experience, in business and industrial psychology domains, provided his expertise regarding the initial list of motivational factors. Then, this initial list of factors was presented in a workshop to 10 construction experts involved in projects in Canada. These experts had an average of 15 years of experience, and they represented different types of construction organizations (e.g., owners, contractors, and labor unions); they also held various positions in their organizations, such as senior management, project management, human resources representative, and labor relations representative. The experts reviewed the list and proposed additional factors they thought may affect construction crew motivation and performance and reached consensus on the proposed additional factors; the primary list of factors was then updated to include the proposed factors. This process allowed for the development of a comprehensive list of factors that not only considers the literature in construction and non-construction domains, but that also captures the opinions of both motivation and construction experts.

The next step in this study was to design and administer the interview surveys. Two separate interview surveys were included in the research to reveal differences between the perspectives of supervisors and craftspeople. In order to identify potential participants, the study methodology and objectives were presented in another workshop to construction companies active in various industrial projects in Canada. A participant company was then selected based on availability of their projects for data collection during the research timeline. Three meetings were held with the survey respondents (i.e., supervisors at the company head office, supervisors in the project field, and craftspeople in the project field) to explain the data collection procedure and the surveys. Sample responses and instructions for completing the surveys were presented to the respondents to ensure respondents understood the surveys. The surveys were performed in the form of structured interview survey were researcher were available for any type of questions and required explanation.

Next, the collected data was analyzed, and the results of the analysis were used to determine the critical factors influencing crew motivation and performance, and to identify the factors with a high potential for improvement. A comparative analysis of supervisor and craft survey results was performed to reveal the differences in perspectives between each group. Statistical tests, including t-tests and F-tests, were performed to determine if there was a statistically significant difference between the mean and variance of the evaluations of supervisors and craftspeople.

Identification of factors

Factors influencing construction crew motivation and performance include a wide range of motivational factors at both individual and crew levels, as well as situational/contextual factors at project and crew levels. Figure 1 shows a model of the relationships of motivational factors and situational/contextual factors to crew performance: the left-hand side of Figure 1 shows motivational concepts, where a number of antecedent factors operate at the individual and group levels to impact crew motivation; the bottom shows the situational/contextual factors that interact with motivation to affect crew performance; and finally, the right-hand side of the model shows crew performance metrics. Crew motivational factors at both the individual and crew levels are shown in Table 1.

In addition to crew motivational factors, situational/contextual factors also affect the performance of construction crews (AbouRizk et al. 2001; Dai et al. 2009; Fayek and Oduba 2005; Knight and Fayek 2000; Liberda et al. 2003). The presence of these factors will either increase or decrease the effect of crew motivation on crew performance. Table 2 shows a complete list of the situational/contextual factor categories, factor sub-categories, and factors in each sub-category.

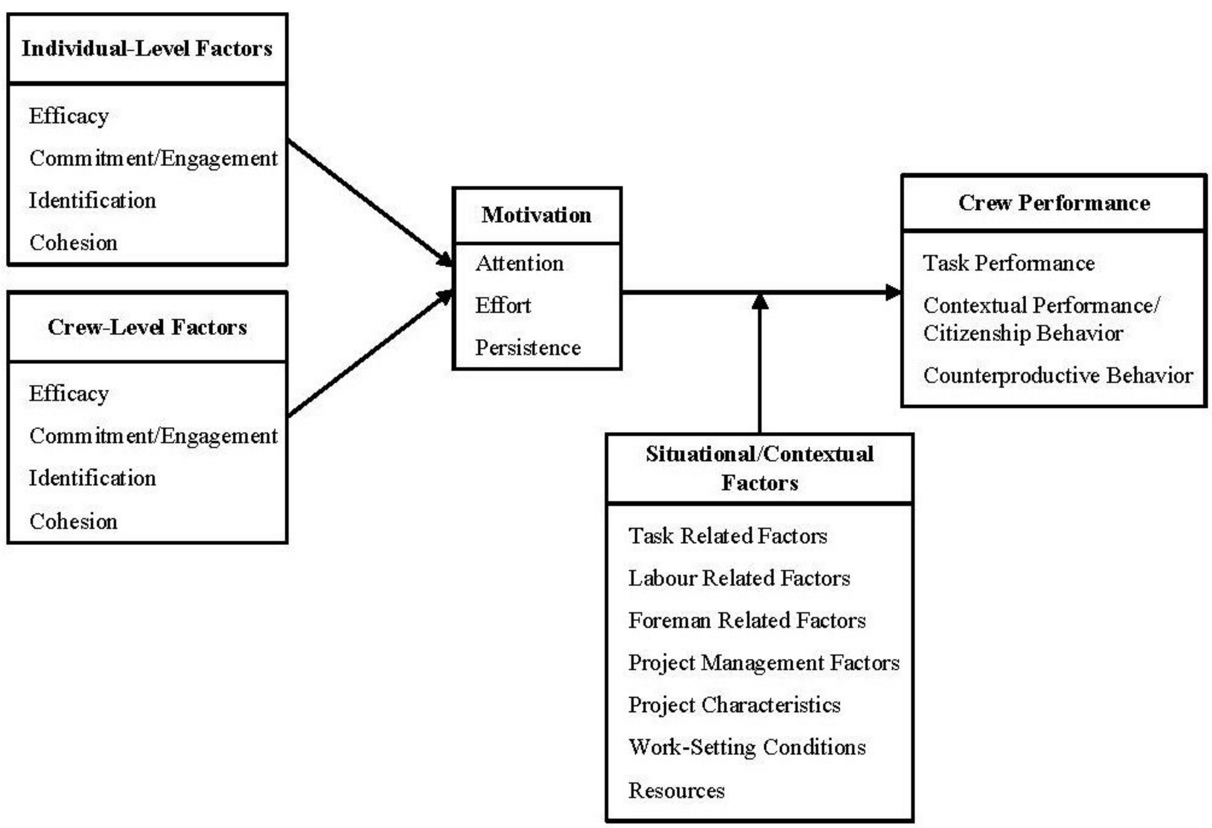

Figure 1. Model of the relationship between motivational factors, situational/contextual factors, and crew performance.

Table 1. Crew motivational factors.

Motivational factor category	Number of factor sub-categories	Factor sub-category	Number of factors	Factors
Individual-level motivational factors	4	• Efficacy–individual level	3	Self-confidence in ability to perform tasks effectively, self-confidence in ability to perform difficult tasks, ability to concentrate on performing tasks
		• Commitment/engagement–individual level	6	Being very happy to spend the rest of career with the organization, seeing the organization's problems as own, sense of "belonging" to the organization, emotional attachment to the organization, feeling like "part of the family" at the organization, the organization having a personal meaning
		• Identification–individual level	4	Feeling proud to be part of the crew, identification with the other members of the crew, like to continue working with the crew, emotional attachment to the crew
		• Cohesion–individual level	5	Choose to stay in the crew, feel to be a part of the crew, like to be with crew members, get along with other crew members, enjoy belonging to the crew
Crew-level motivational factors	4	• Efficacy–crew level	3	Crew confidence in ability to perform tasks effectively, crew confidence in ability to perform difficult tasks, crew ability to concentrate on performing tasks
		• Commitment/engagement–crew level	6	Crew members to be very happy to spend the rest of career with the organization, crew members to see the organization's problems as own, crew's sense of "belonging" to the organization, crew's emotional attachment to the organization, crew members to feel like "part of the family" at the organization, the organization having a personal meaning to the crew
		• Identification–crew level	4	Crew members to feel proud to be part of the crew, crew members identification with the other members of the crew, crew members to like to continue working with the crew, Crew members' emotional attachment to the crew
		• Cohesion–crew level	3	Crew members get along well together, defending each other from criticism, crew being a close one
Total	**8**		**34**	

Table 2. Situational/contextual factors.

Situational/ contextual factor category	Number of factor sub-categories	Factor sub-category	Number of factors	Factors
Task-related	3	• Task characteristics	5	Task type, task size, task complexity, task repetition, task interruption and disruption
		• Task design	7	Skill variety, task identity, task significance, visibility of outcome, flexibility in scheduling, flexibility in procedures, feeling of ownership
		• Rework	5	Rework type, rework frequency, level of rework, rework time requirement, rework source
Labour-related	3	• Crew properties	4	Crew size, crew composition, crew knowledge, crew experience
		• Crew functional skills	5	Job training, safety training, ability to perform, material handling, hazards identification and mitigation
		• Crew behavioral skills	6	Cooperation, teamwork, trust in foreman, participation in decision-making, reliability, adaptability to changes
Foreman-related	3	• Foreman characteristics	4	Foreman age, foreman gender, foreman knowledge, foreman experience
		• Foreman functional skills	7	Planning, scheduling, safety facilitation and implementation, resource management, performance monitoring, communication, team building
		• Foreman behavioral skills	8	Goal setting, feedback, leadership, fairness, decision-making style, teamwork, working relationship, building trust
Project characteristics	3	• Project properties	4	Project type, project size, project duration, project location
		• Work/job conditions	5	Working shifts, daily working hours, camp, work permits, project progress
		• Project engineering	5	Drawings availability, specifications availability, drawing and specs quality, response to inquiries, frequency of revisions
Management-related	4	• Project manager characteristics	4	PM age, PM gender, PM knowledge, PM experience
		• Project manager functional skills	7	Project planning, project scheduling, safety management, resource management, performance monitoring & control, change management, communication
		• Project manager behavioral skills	6	Leadership, fairness, goal-setting, feedback, conflict resolution, trust

Situational/ contextual factor category	Number of factor sub-categories	Factor sub-category	Number of factors	Factors
		• Project and construction management practices	13	Project integration management, project scope management, project time management, project cost management, project quality management, project human resource management, project communication management, project risk management, project procurement management, project safety management, project environmental management, project financial management, project claim management
Work-setting conditions	3	• Site general facilities	5	Office, lunchroom, washrooms, in-site transportation, communication device
		• Working area conditions	7	Cleanness, congestion, noise, pollution, type (covered/ uncovered), ventilation/air conditioning, access points
		• Weather conditions	5	Temperature, humidity, precipitation, wind speed, change in weather conditions
Resources	3	• Material	4	Task material availability, task material quality, consumables availability, consumables quality
		• Equipment	3	Equipment type, equipment availability, equipment quality
		• Tools	3	Type of tools, tools availability, tools quality
Safety	1	• Safety precautions	7	Safety procedures, safety meetings, safety inspections, safety audits, protective safety gears, safety training, recording incidents & corrective actions
Total	**23**		**129**	

Interview survey design

Two interview surveys – the supervisor and craft surveys – were developed in order to achieve three design objectives: identify critical factors relevant to supervisors and craftspeople; identify potential areas of improvement in construction crew motivation and performance; and reveal differences between supervisors and craftspeople perspectives by comparing respondents' rankings of common factors included in both surveys. The interview surveys address factors and their effects on crew motivation and performance at the following levels of analysis: micro-level (i.e., individual level), meso-level (i.e., crew level), and macro-level (i.e., project level) factors.

Both interview surveys included three sections: background, motivational factors, and situational/contextual factors. The first section was designed to collect respondent attributes such as age, occupation, experience, and other demographic information. The second section asked survey respondents to evaluate the motivational factors, while the third section involved the evaluation of project situational/contextual factors. In the second and third sections, for each survey question, respondents were asked to provide answers in two different areas: agreement (i.e., the extent to which the respondent agrees that a given factor exists in the project), and importance (i.e., how important a factor is in evaluating its factor sub-category). As proposed by Dai et al. (2009), a seven-point Likert scale was adopted to evaluate agreement and importance. Agreement was measured on a scale ranging from one ("strongly disagree") to seven ("strongly agree"), and importance was measured on a scale ranging from one ("extremely unimportant") to seven ("extremely important").

The supervisor survey included all crew-level motivational factors (i.e., "cohesion", "efficacy", "identification", and "commitment/engagement"), and all situational/contextual factors (i.e., "task-related factors", "labor-related factors", "foreman-related factors, "project management", "work-setting conditions", "resources", "project characteristics", and "safety"), amounting to a total of 137 factors in 9 categories and 26 sub-categories. The craft survey included all individual-level and crew-level motivational factors (i.e., "cohesion", "efficacy", "identification", and "commitment/engagement"), and some situational/contextual factors (i.e., "task-related factors", "labor-related factors", "foreman-related factors", "project management", "work-setting conditions", and "resources"), amounting to a total of 126 factors in 8 categories and 26 sub-categories (see Table 3 for a comprehensive list of these factors).

Table 3. Factors in surveys.

Factor category	Number of factors		
	Supervisor survey	Craft survey	Common to both surveys
Individual-level motivational factors	-	18	-
Crew-level motivational factors	16	16	16
Task-related	16	16	16
Labour-related	16	16	16
Foreman-related	19	19	19
Project characteristics	10	-	-
Management-related	28	15	15
Work-setting conditions	16	16	16
Resources	10	10	10
Safety	6	-	-
Total	**137**	**126**	**108**

It is important to determine similarities and differences among the rankings of common factors evaluated by both supervisors and craftspeople in order to find and implement effective improvement strategies. While a higher level of agreement on factors between the two groups will help in implementing improvement strategies, a lack of agreement will demand further investigation into the sources of these differences. In order to investigate respondent perspectives, a total of 108 factors in 7 categories and 22 sub-categories were included in both the supervisor survey and the craft survey (Table 3).

Case study of Survey Administration and Analysis

As a case study, the interview surveys were administered to a construction company active in various industrial projects in Canada. Following several meetings with managers of the participating company, the interview survey procedures were finalized, and researchers coordinated with project staff to administer the surveys. For both surveys, participants were identified using a stratified random sampling method. All data were collected in confidence and anonymity was maintained. Participants were also informed of the study goals, and written consent was collected. Each interview was designed to last for approximately 30 minutes, and all interviews were conducted in an environment specifically selected to protect the privacy of participants. All collected interview surveys were then anonymized using a code sheet.

Determination of sample size (i.e., the number of respondents to be surveyed from the population of workers) is essential to ensure the reliability and accuracy of results. Since the interview surveys were designed to address factors from the individual level up to the project level, respondents representing each of these different levels were asked to participate in the study (Dai et al. 2009; Jergeas 2009). The population (i.e., the number of workers in a given project) for the interview survey was assumed to be made up of all construction personnel on the project under study. This population composition ensures that the critical factors identified through the interview survey are applicable to the company's context and its project work force.

The interview survey population was stratified into the following levels: senior management, project management, construction management, superintendents, project staff (e.g., project controls, site project manager, project coordinator, and safety officer), foremen, and craftspeople. Once the population for each stratum was established, random sampling was applied. Stratified random sampling is an appropriate method in this situation since the structure within the population of each stratum is assumed to be similar in terms of role and function. Additionally, an adequate sample size was used to ensure proper representation of the population as a whole (Fellows and Liu 2015). Random sampling also ensures that respondents have an equal chance of being selected, which helps to prevent biased selection based on convenience (Robinson 2014).

After defining the population, craft surveys were administered to craftspeople, and supervisor surveys were administered to all other personnel. A construction company with 25 supervisors and 54 craftspeople participated in the study, for a total population of 79 people. From 25 supervisors, 23 responded to the supervisor survey, and from 54 craftspeople, 15 responded to the craft survey.

Considering the total population, 37 respondents were required to achieve a 90% confidence level with a 10% margin of error. Since there were 38 respondents for this study, the required 90% confidence level was achieved. However, it should be noted that the response rate of supervisors was higher than that of craftspeople. Considering each survey population separately, 23 of 25 supervisors responded, which provided more than a 99% confidence level with a 10% margin of error. From 54 craftspeople, 15 responded, which provided an 80% confidence level with a 10% margin of error.

Survey respondents demographics

Supervisor survey respondents held the following positions: senior manager, construction manager, project manager, executive manager, superintendent, project controller, field engineer, field supervisor, safety/HSE officer, QA/QC manager, and foreman. Most supervisors were foremen, making up 31% of supervisor survey respondents. Craft survey respondents identified their trades as laborer, pipeliner, welder, sandblaster, pipe coater, and other (e.g., flagger). In terms of trade, most of the craftspeople (i.e., 57% of craft survey respondents) identified their trade as laborer. Figure 2 shows the distribution of respondents by age group. Most of the supervisor survey respondents were between 36 and 45 years of age, while most of the craft survey respondents were between 26 and 35 years of age. Figure 3 shows the distribution of respondents by experience. Supervisor survey respondents had an average of 11 years of experience, while craft survey respondents had an average of 5 years of experience in their trade. As shown in Figures 2 and 3, supervisors were older and had more experience than craftspeople.

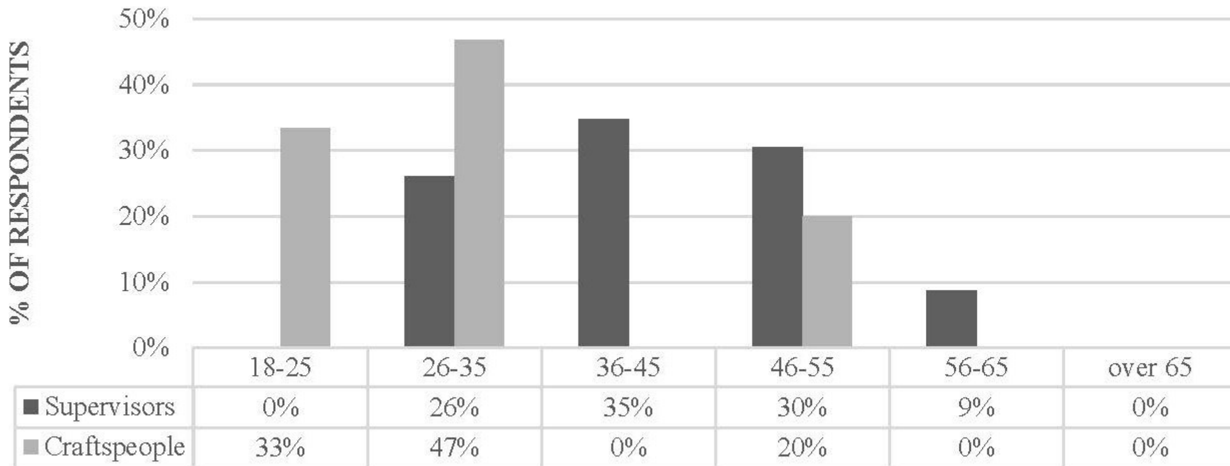

Figure 2. Distribution of respondents by age group.

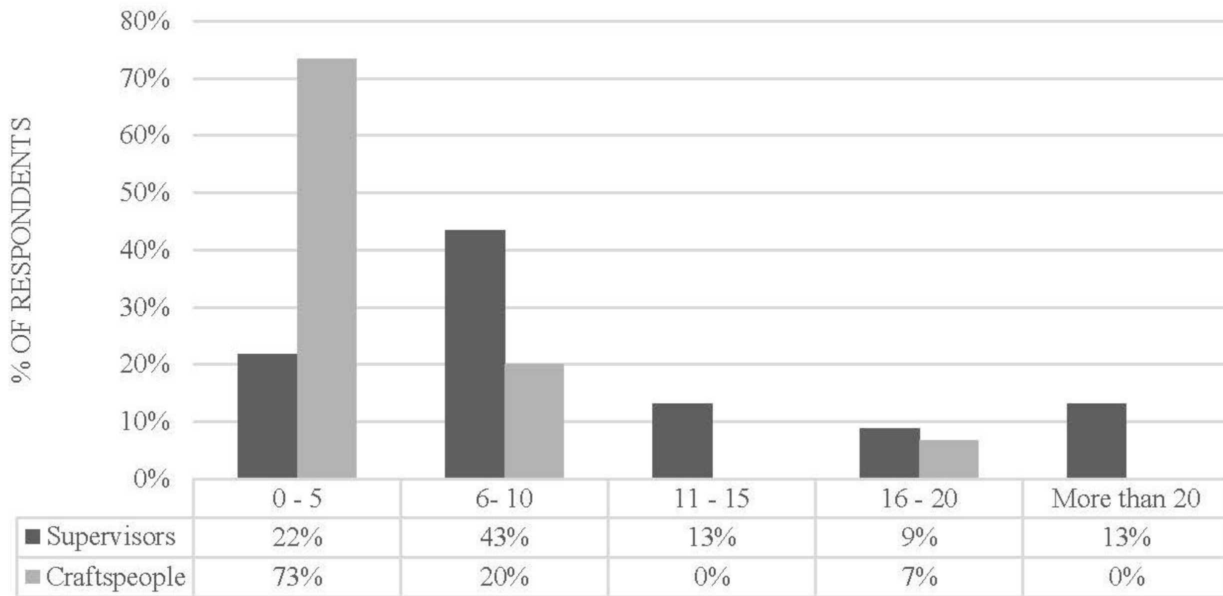

Figure 3. Distribution of respondents by years of experience.

Critical factors influencing construction crew motivation and performance

To identify the critical factors affecting construction crew motivation and performance, factor rank was calculated based on evaluation scores, the latter of which take into consideration both the agreement and importance of factors. This type of ranking was used previously by Dai et al. (2009) and was expanded by Tsehayae and Fayek (2014) to identify critical factors affecting productivity. In this paper, a similar analytical concept was adopted with some differences in formulation. These differences originate from the fact that in the previous works, evaluation scores were based on agreement-impact, while this paper bases evaluation scores on agreement-importance.

All factors were analyzed as follows. First, the weighted percentage of agreement (R_A) for a given factor statement is computed using Equation 1, where the maximum possible weighted percentage of agreement is 25. The agreement is the extent to which a respondent agrees that a given factor exists in the project. Thus, R_A represents the level of agreement of all the respondents with the existence of a given factor in the project.

$$R_A = \frac{(A\times1+B\times2+C\times3+D\times4+E\times5+F\times6+G\times7)}{(1+2+3+4+5+6+7)}\ x\ 100, \quad (1)$$

where A, B, C, D, E, F, and G are the percentage of respondents rating the agreement with the existence of the factor in the project from 1 ("strongly disagree") to 7 ("strongly agree") respectively.

Next, the weighted percentage of relative importance (R_I) of a given factor statement is computed using Equation 2, where the maximum possible weighted percentage of relative importance is equal to 25.

$$R_I = \frac{(T\times1+U\times2+V\times3+W\times4+X\times5+Y\times6+Z\times7)}{(1+2+3+4+5+6+7)}\ x\ 100, \quad (2)$$

where T, U, V, W, X, Y, and Z are the percentage of respondents rating the importance of the factor from 1 ("extremely unimportant") to 7 ("extremely important") respectively.

Next, the evaluation index and evaluation scores for each factor are computed using Equation 3 and Equation 4 respectively. The evaluation index, which is the product of the weighted percentage of agreement (R_A) and the weighted percentage of relative importance (R_I), is calculated first. Then, the evaluation score is computed by dividing the evaluation index of a given factor by the maximum possible evaluation score (i.e., 625). The maximum possible evaluation score is the product of the maximum values of the weighted percentage of agreement (i.e., 25) and the relative importance (i.e., 25).

$$Evaluation\ Index_{AI} = R_A \times R_I. \tag{3}$$

$$Evaluation\ Score_{AI} = \frac{Evaluation\ Index_{AI}}{625} \times 100. \tag{4}$$

After the interview surveys were administered, responses were combined and the evaluation scores were calculated. Each factor's rank was then determined based on its evaluation score. Since the analysis was based on the agreement-importance of each factor, the critical factors influencing crew motivation and performance are the ones that showed high agreement and high importance. Factor category and sub-category rankings are presented in Table 4 for both supervisor and craft surveys. These rankings are based on the average evaluation scores of factors in each category and sub-category.

The results in Table 4 show that supervisors ranked "safety", "resources", and "labor-related factors" as the top three factor categories influencing crew motivation and performance, while they ranked "equipment", "safety precautions", "foreman characteristics", "tools", and "crew functional skills" as the top five factor sub-categories influencing crew motivation and performance. On the other hand, craftspeople ranked "foreman-related factors", "labor-related factors", and "project management factors" as the top three factor categories influencing crew motivation and performance, while they ranked "foreman characteristics", "collective efficacy", "self-efficacy", "project manager characteristics", and "crew behavioral skills" as the top five factor sub-categories influencing construction crew motivation and performance.

Table 4. Factor category and factor sub-category rankings.

Factor category	Factor sub-category	Supervisor survey		Craft survey	
		Rank of category	Rank of sub-category	Rank of category	Rank of sub-category
Individual-level motivational factors	• Cohesion–individual level	-	-	5 (88.14)	11 (88.24)
	• Efficacy–individual level		-		**3 (98.38)**
	• Identification–individual level		-		15 (82.18)
	• Commitment/engagement–individual level		-		22 (65.39)
Crew-level motivational factors	• Cohesion–crew level	6 (78.40)	14 (85.03)	6 (88.11)	8 (91.06)
	• Efficacy–crew level		7 (92.22)		**2 (98.71)**
	• Identification–crew level		16 (77.58)		16 (80.49)
	• Commitment/engagement– crew level		25 (58.33)		24 (63.83)
Task-related factors	• Task characteristics	9 (65.80)	23 (68.23)	8(67.72)	20 (71.43)
	• Task design		19 (74.93)		21 (66.81)
	• Rework		26 (53.96)		26 (54.34)
Labour-related factors	• Crew properties	**3 (93.29)**	11 (91.00)	**2 (94.83)**	14 (83.00)
	• Crew functional skills		**5 (95.19)**		7 (91.79)
	• Crew behavioral skills		6 (93.29)		**5 (94.88)**
Foreman-related factors	• Foreman characteristics	4 (91.68)	**3 (96.84)**	**1 (100.00)**	**1 (100.00)**
	• Foreman functional skills		9 (91.40)		6 (93.83)
	• Foreman behavioral skills		13 (86.41)		9 (90.55)
Project characteristics	• Project properties	7 (74.78)	-	-	-
	• Work/job conditions		18 (75.16)		-
	• Project engineering		21 (74.20)		-
Management-related factors	• Project manager characteristics	5 (83.75)	10 (91.04)	**3 (91.75)**	**4 (96.12)**
	• Project manager functional skills		15 (81.92)		17 (79.41)
	• Project manager behavioral skills		12 (87.19)		13 (85.39)
	• Project and construction management practices		20 (74.38)		-
Work-setting conditions	• Site general facilities	8 (72.43)	17 (76.33)	7 (69.57)	19 (72.12)
	• Working area conditions		24 (67.09)		25 (60.89)
	• Weather conditions		22 (73.57)		23 (64.85)
Resources	• Material	**2 (96.20)**	8 (91.57)	4 (89.15)	18 (77.39)
	• Equipment		**1 (100.00)**		12 (87.57)
	• Tools		**4 (96.62)**		10 (88.56)
Safety	• Safety precautions	**1 (100.00)**	**2 (99.86)**	**-**	**-**

[a] The values in brackets indicate the normalized evaluation scores.

Table 5 lists the top 10 critical factors influencing crew motivation and performance, as ranked by the supervisor survey and craft survey respondents. Out of the 137 factors included in the supervisor survey, respondents ranked “using protective safety gears for performing the tasks”, "ability of crew to identify hazards and mitigate the risks associated with them", "quality of equipment for performing the task", "cooperation among the members of the crew", and "team work in the crew" as the top five critical factors influencing crew motivation and performance. On the other hand, out of the 126 factors included in the craft survey, respondents identified "confidence of crew members that they can successfully perform difficult tasks", "mutual trust between foreman and crew members", "crew members believe in their ability to perform the tasks", "foreman has the required knowledge of the work", and "foreman has the required experience to define procedures for performing the tasks" as the top five factors influencing crew motivation and performance.

Table 5. Top 10 critical factors influencing construction crew motivation and performance.

Rank	Supervisor survey		Craft survey	
	Factor	**Evaluation score**	**Factor**	**Evaluation score**
1	Protective safety gear is mandatory for performing the tasks.	100.00	The members of this crew feel confident that they can successfully perform difficult tasks.	100.00
2	The members of this crew can identify hazards and mitigate the risk associated with them.	94.88	There is high mutual trust between the foreman and crew members	99.67
3	The quality of equipment is suitable for performing the task.	91.79	The members of this crew believe in their ability to perform the tasks effectively.	99.05
4	Cooperation among the members of this crew is high.	91.17	The foreman has the required knowledge of the work.	99.04
5	Teamwork in this crew is good.	91.17	The foreman has the required experience to define procedures for performing the tasks.	99.04
6	Equipment is available for performing the task.	89.95	I feel confident in my ability to perform my tasks effectively.	99.04
7	The members of this crew have adequate ability to perform the tasks with required quality.	89.92	The foreman has leadership in managing the crew.	98.62
8	The foreman has the required knowledge of the work.	89.92	The foreman has appropriate skills in resource management.	98.08
9	Safety rules and procedures are followed on this project.	89.54	The foreman has effective working relationships with crew members.	97.59
10	Safety procedures are defined appropriately in this project.	89.35	The members of this crew trust in the foreman's judgments and decisions.	97.12

Factors with a high potential for improvement in construction crew motivation and performance

Factors influencing construction crew motivation and performance are important targets for improvement, or if they are already fully satisfied, it is vital to make efforts to keep them at their highest possible agreement level. However, improving a factor that is already close to its highest possible agreement level is very difficult and is sometimes not feasible. Therefore, this section illustrates a method of analysis to identify factors with a high potential for improvement in crew motivation and performance; these are the factors that simultaneously exhibit a low level of agreement and a high level of importance. To determine the lowest possible level of agreement, the weighted percentage of disagreement is calculated using the inverse of the calculations for the weighted percentage of agreement. The potential improvement of each factor is then calculated using the weighted percentage of disagreement and the weighted percentage of relative importance to each factor. All factors have been analyzed using the calculations presented below.

First, the weighted percentage of disagreement (R_D) for a given factor statement by a number of respondents is computed using Equation 5, where the maximum possible weighted percentage of disagreement is 25. The calculations for the weighted percentage of disagreement are the inverse of the calculations for the weighted percentage of agreement.

$$R_D = \frac{(A\times7+B\times6+C\times5+D\times4+E\times3+F\times2+G\times1)}{(1+2+3+4+5+6+7)}\ x\ 100, \tag{5}$$

where A, B, C, D, E, F, and G are the percentage of respondents rating the agreement of the factor as 1 (“strongly disagree”) to 7 (“strongly agree”) respectively.

The relative importance (R_I) of a given factor statement is computed using Equation 2, where the maximum possible weighted percentage of relative importance is 25. Next, the level of potential improvement for each factor is evaluated by calculating the potential improvement index Equation 6 and the potential improvement score Equation 7. First, the potential improvement index is calculated as the product of the weighted percentage of disagreement (R_D) and the weighted percentage of relative importance (R_I). Next, the potential improvement score is computed by dividing the potential improvement index of a given factor by the maximum possible potential improvement score. The maximum possible potential improvement score is 625, which is the product of the maximum values of the weighted percentage of disagreement (i.e., 25) and the weight percentage of relative importance (i.e., 25):

$$Potential\ Improvement\ Index_{DI} = R_D \times R_I. \quad (6)$$

$$Potential\ Improvement\ Score_{DI} = \frac{Potential\ Improvement\ Index_{DI}}{625} \times 100. \quad (7)$$

The interview survey responses were combined and the calculations for potential improvement scores were performed. Each factor's rank was then determined based on its potential improvement score. Since the analysis was based on the disagreement-importance of each factor, the factors with a high potential for improvement in construction crew motivation and performance are the ones that showed low agreement and high importance. Table 6 lists the top 10 factors with a high potential for improvement in construction crew motivation and performance, as ranked by the supervisor survey and craft survey respondents.

The factors listed in Table 6 are the ones that have both a low level of agreement and a high level of importance. For such factors, if the agreement levels are increased (i.e., if respondents display a high level of agreement regarding the existence of these factors on a project), since those factors demonstrate high levels of importance, the motivation and performance of the crew will be improved. Therefore, identifying the factors with a high potential for improvement in construction crew motivation and performance will provide companies with insight into factors that may possibly affect crew performance on future projects. Supervisor survey respondents identified "more freedom should be granted to crew members in selecting work procedures", "the working area should be protected from the effects of wind", and "more freedom should be granted to crew members in scheduling their tasks" as the top three factors with a high potential for improvement in crew motivation and performance. On the other hand, craft survey respondents suggested "the work area should be protected from the effects of overall weather effects", "the work area should

Table 6. Top 10 factors with a high potential for improvement in construction crew motivation and performance.

Rank	Supervisor survey		Craft survey	
	Factor	Evaluation score	Factor	Evaluation score
1	The members of this crew have a high degree of freedom in selecting the procedures to be used in carrying out their tasks.	100.00	The work area is protected from overall weather effects.	100.00
2	Working area is protected from wind effects (e.g. working area is a closed area).	99.83	Working area is protected from precipitation (e.g. working area is a covered area).	94.86
3	The members of this crew have a high degree of freedom in scheduling their tasks.	96.22	Working area is protected from wind effects (e.g. working area is a closed area).	93.67
4	Working area is protected from precipitation (e.g. working area is a covered area).	96.22	The members of this crew have a high degree of freedom in selecting the procedures to be used in carrying out their tasks.	83.32
5	The work area is protected from overall weather effects.	95.09	The goals assigned by the foreman to the crew are difficult.	82.45
6	This company or labor union has a great deal of personal meaning for the members of this crew.	90.85	The members of this crew have a high degree of freedom in scheduling their tasks.	79.15
7	The goals assigned by the foreman to the crew are difficult.	88.60	The members of this crew are very happy to spend the rest of their career with this company or labor union.	65.60
8	Actual progress of the project is based on project estimates.	87.42	Working area is usually not congested.	64.77
9	Types of reworks are very similar in this project.	86.96	On average, the weather conditions (temperature, wind, humidity, precipitation) are normal in the working area.	62.81
10	Working area is usually not congested.	84.59	The members of this crew feel "emotionally attached" to this company or labor union.	62.51

be protected from precipitation", and "the work area should be protected from wind" as the top three factors with a high potential for improvement.

Comparative analysis of supervisor and craft survey results

Past productivity research also includes perspective analysis to compare the responses of project managers or foremen with the responses of tradespeople on factors affecting productivity (Dai et al. 2009; Tsehayae and Fayek 2014). In this paper, the perspectives of supervisors and craftspeople are compared on three levels: rankings of common factor categories, rankings of common factor subcategories, and rankings of common factors between the two surveys. Between the supervisor and craft surveys, 108 common factors in 7 categories and 22 sub-categories have been evaluated. Rankings for the common factors were derived from the evaluation scores, which were then normalized based on the maximum score. The rankings for the common factor sub-categories are based on the average evaluation scores of factors in each sub-category, while the rankings for the common factor categories are based on the average evaluation scores of factor sub-categories. It should be noted that since these rankings were recalculated to only include the factor categories, sub-categories, and factors that exist in both the supervisor and craft surveys, rankings in this section may differ from those shown in Tables 5 to 7. The results show strong agreement by the respondent groups on critical factor categories and sub-categories common to both interview surveys. From the top three critical factor categories identified by supervisors, two were also identified as top three critical factor categories by craft survey respondents: "labor-related factors" and "foreman-related factors". Surprisingly, 8 factor sub-categories out of 10 were identified by both respondent groups as the top 10 critical factor sub-categories influencing construction crew motivation and performance.

The differences in evaluation scores between the respondent groups were also calculated. Table 7 lists the top 10 factors with the greatest difference in evaluation scores between supervisors and craftspeople. The factors with the greatest difference in evaluations were "task complexity", "participation of crew members in decision-making", and "foreman decision-making style". Statistical tests were performed to investigate if there is a statistically significant difference between each group's evaluations. Previous researchers, such as Tsehayae and Fayek (2014) and Dai et al. (2009), used F-tests on the impact scores; in this paper, both t-tests and F-tests were performed. Since the respondents were from different populations, unpaired t-test assuming unequal variance was performed to determine if there is a statistically significant difference between the mean values of each respondent group's evaluations scores. The null hypothesis is that there is no statistically significant difference between these means values. A 95% confidence level was assumed and thus a p-value (i.e., the probability value that the null hypothesis is true) of 0.05 was considered in the calculations. Table 8 shows the t-values for each factor. For the items where the t-value exceeds t-critical (i.e., 2.03), the null hypothesis is rejected, which means that there is a statistically significant difference between the mean values of each respondent group's evaluations. The results in Table 8 show that for some factors (i.e., "task complexity", "participation of crew members in decision-making", and "foreman decision-making style"), there is a statistically significant difference between each group's evaluations. However, the results suggest that some factors, such as "the organization having a personal meaning to the crew", do not show a statistically significant difference.

In addition to the t-test, an F-test was performed to determine out if there is a statistically significant difference between the variance of the evaluations of supervisors and craftspeople. The null hypothesis is that there is no statistically significant difference between the variance of the evaluations. A 95% confidence level was assumed, and a p-value of 0.05 was considered in the calculations. F-values for each factor are presented in Table 8. For the items in which the F-value exceeds F-critical (i.e., 2.36), the null hypothesis is rejected, which means that there is a statistically significant difference between the variance of the evaluations. The results of the *F*-test are very similar to that of the *t*-test, indicating that for some factors, there is a statistically significant difference between the evaluations of supervisors and craftspeople. Identifying the factors for which there are differences in evaluations will help to mitigate or eliminate the sources of differences between supervisors and craftspeople, leading to an improved understanding of the work environment and to improved crew performance.

Table 7. Top 10 factors with a high difference in evaluation scores.

Rank	Factor	Supervisors Evaluation score	Craftspeople Evaluation score	Difference	*t*-value[a]	*F*-value[b]
1	Tasks are very complex in this project.	45.96	70.69	24.73	3.22[c]	3.15[d]
2	The members of this crew try to participate in decision-making process.	68.51	91.42	22.92	2.49[c]	5.27[d]
3	The foreman decision-making style related to work issues is participative rather than autonomous.	75.23	96.57	21.34	2.90[c]	3.92[d]
4	This company or labour union has a great deal of personal meaning for the members of this crew.	46.85	67.92	21.07	1.57	1.26
5	Crew members can participate in goal setting.	71.40	90.40	19.00	2.92[c]	4.05[d]
6	The foreman has appropriate skills in resource management.	79.68	98.08	18.40	2.73[c]	2.88[d]
7	The members of this crew will readily defend each other from criticism by outsiders.	73.08	91.39	18.32	2.60[c]	1.58
8	The members of this crew really feel as if this company or labour union's problems are their own.	45.16	60.84	15.68	1.76	1.41
9	This crew is a close one.	75.26	90.50	15.24	2.88[c]	3.20[d]
10	The foreman treats all crew members equally and fairly.	81.33	96.56	15.23	1.96	2.42[d]

[a] *t*-values are calculated based on importance scale and *t*-critical for *t*-test is 2.03.
[b] *F*-values are calculated based on importance scale and *F*-critical for *F*-test is 2.36.
[c] Indicates that the difference between the mean values of the evaluation scores of supervisors and craftspeople were statistically significant at $p < 0.05$.
[d] Indicates that the difference between the variances of evaluation scores of supervisors and craftspeople were statistically significant at $p < 0.05$.

Table 1. Top 10 factors with a high difference in evaluation scores.

Rank	Factor[e]	Supervisors Evaluation score	Craftspeople Evaluation score	Difference	*t*-value[a]	*F*-value[b]
1	Tasks are very complex in this project.	45.96	70.69	24.73	3.22[c]	3.15[d]
2	The members of this crew try to participate in decision-making process.	68.51	91.42	22.92	2.49[c]	5.27[d]
3	The foreman decision-making style related to work issues is participative rather than autonomous.	75.23	96.57	21.34	2.90[c]	3.92[d]
4	This company or labor union has a great deal of personal meaning for the members of this crew.	46.85	67.92	21.07	1.57	1.26
5	Crew members can participate in goal setting.	71.40	90.40	19.00	2.92[c]	4.05[d]
6	The foreman has appropriate skills in resource management.	79.68	98.08	18.40	2.73[c]	2.88[d]
7	The members of this crew will readily defend each other from criticism by outsiders.	73.08	91.39	18.32	2.60[c]	1.58
8	The members of this crew really feel as if this company or labor union's problems are their own.	45.16	60.84	15.68	1.76	1.41
9	This crew is a close one.	75.26	90.50	15.24	2.88[c]	3.20[d]
10	The foreman treats all crew members equally and fairly.	81.33	96.56	15.23	1.96	2.42[d]

[a] *t*-values are calculated based on importance scale and *t*-critical for *t*-test is 2.03.

[b] *F*-values are calculated based on importance scale and *F*-critical for *F*-test is 2.36.

[c] Indicates that the difference between the mean values of the evaluation scores of supervisors and craftspeople were statistically significant at $p < 0.05$.

[d] Indicates that the difference between the variances of evaluation scores of supervisors and craftspeople were statistically significant at $p < 0.05$.

[e] Factors in bold are the ones that show statistically significant differences between the perspectives of supervisors and craftspeople.

Discussion

Supervisors considered “equipment”, “safety precautions”, “foreman characteristics”, “tools”, and “crew functional skills” as the major factors influencing construction crew motivation and performance. Three of those factors (i.e., “equipment”, “safety precautions”, and “tools”) can be managed through precise project planning and monitoring, while the other two (i.e., “foreman characteristics" and "crew functional skills") can be addressed by improving the experience and skills of foreman and craftspeople through training programs. These findings are in line with the study done by Dai et al. (2009), which found that craftspeople identified equipment and tools among their top five factors influencing productivity, and made the recommendation that job site managers focus on control of equipment and tools (Dai et al. 2009). Similar to the results presented in this paper, "foremen characteristics" and "crew functional skills" were also identified in past research as affecting crew motivation and performance (Maloney and McFillen 1987; Siriwardana and Ruwanpura 2012). However, "safety precautions" were not identified as a critical factor affecting construction crew motivation and performance in previous studies; this may indicate that the company under study had a high safety culture and that supervisors perceive safety precautions as a critical factor.

Craftspeople considered "foreman characteristics", "collective efficacy", "self-efficacy", "project manager characteristics", and "crew behavioral skills" as the major factors influencing construction crew motivation and performance. Two of these factors (i.e., "foreman characteristics" and "project manager characteristics") concur with findings from Maloney (1986), which identified the characteristics and behavior of the supervisor as one of the factors affecting the motivation of workers. The other two factors related to efficacy were in agreement with the results provided by other researchers on motivation in construction discussed earlier (Siriwardana and Ruwanpura 2012). That being said, previous research studied efficacy only at the individual level, while this paper expands motivational concepts to the crew level. Additionally, the results of this study identified crew behavioral skills as a critical factor affecting construction crew motivation and performance, while past research in construction focused only on crew functional skills (Maloney and McFillen 1987; Siriwardana and Ruwanpura 2012).

Supervisors identified the following factors as having a high potential for improvement in construction crew motivation and performance: “freedom of crew members in selecting work procedures and scheduling their tasks” and “the protection of working area from the effects of wind”. On the other hand, craftspeople identified the following as factors with a high potential for improvement: “protection of working area from overall weather effects”, “precipitation”, and “wind”. These results indicate that crew performance may improve with favorable weather conditions. Similarly, giving more freedom to crew members in selecting work procedures or scheduling their tasks may increase their motivation and performance. The identification of potential improvement factors are context specific and may vary from project to project. However, awareness of the factors that may contribute to significant improvements in crew motivation and performance might help project managers to improve company policies and procedures.

While the results of the comparative analysis suggest that there is high agreement between the perspectives of supervisors and craftspeople, there are still some areas of disagreement. There were statistically significant differences between each group’s perspectives in terms of the mean and variance of the evaluation scores for “task complexity”, “crew participation in decision-making”, and “foreman decision-making style”. The results indicate that craftspeople believed that task complexity was a critical factor affecting their motivation and performance, while supervisors did not see task complexity as a critical factor in the project. The results also indicate that craftspeople would like more involvement in decision-making, while supervisors did not consider the involvement of craftspeople to be a critical factor. Dai et al. (2009) identified a high level of agreement between supervisors and craftspeople, while Tsehayae and Fayek (2014) observed both agreement and disagreement between the perspectives of supervisors and craftspeople. The results of this study are thus in agreement with the research of Tsehayae and Fayek (2014).

Conclusions

Past research on motivation in the construction domain has not only been relatively limited, but it also demonstrates issues in areas such as use of outdated theories of motivation, failure to incorporate recent motivational concepts developed by researchers outside the construction domain, and a tendency to only focus on individual-level motivation. In turn, these gaps in the literature present challenges to researchers in defining crew motivation in construction, as well as in identifying the crew motivational factors and situational/contextual factors affecting crew motivation and performance. This paper bridges these gaps by exploring more recent motivational concepts that were introduced and advanced in non-construction domains. Furthermore, to capture the reality of construction crew dynamics, this paper examined the motivational factors that operate at both individual and crew levels. Four motivational concepts were identified that operate at both levels: efficacy, commitment/engagement, identification, and cohesion.

Next, this paper provided a methodological approach, which was applied to identify and assess the factors affecting construction crew motivation and performance. A list of 163 factors was identified from existing research in both construction and non-construction domains; this list was validated by both motivation and construction experts and updated based on their recommendations. The methodology of the paper was then tested through a case study to determine its practicality. Critical factors, as well as factors with a high potential for improvement in crew motivation and performance, were identified, and the perspective of supervisors and craftspeople on critical factors affecting crew motivation and performance were compared. The results of both the *t*-test and *F*-test indicate that there were some areas of disagreement between supervisors and craftspeople. These statistical tests consider the sample size in calculating the critical values (i.e., *t*-critical and *F*-critical) and are thus able to identify if there is a significant difference between the perspectives of two populations, even if the respondents' sample sizes are small. However, because of the limitation in the sample size of craft survey respondents, the results associated with this group are limited to the given context and need additional investigation in order to generalize them.

This paper makes three contributions: first, it provides a comprehensive set of factors affecting crew motivation and performance; second, it presents a novel methodology for identifying and measuring motivational factors at both the individual and crew levels; and third, it defines a methodology to evaluate and rank critical factors and factors with a high potential for improvement in construction crew motivation and performance and to evaluate the differences between the perspectives of supervisors and craftspeople on the identified critical factors.

In addition to the data collected through interview surveys, field data were also collected from a Canadian construction project. In the future, data analysis based on the collected project field data will be performed to determine the strength of the relationships between motivational factors and crew performance, and to identify factors influencing these relationships. The identified list of factors in this paper, as well as the results of future field data analysis, will be used to develop models that describe the relationship between motivational factors, crew motivation, and crew performance.

Data Availability

All data generated or analyzed during the study are included in the submitted article or supplemental materials files.

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