Key Moderators of the Relationship Between Construction Crew Motivation and Performance

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Abstract

Construction crew performance is a function of both motivation and the situation in which tasks are performed. However, previous research in construction has not comprehensively investigated situational/contextual factors and their impact on the relationship between motivation and performance. This paper defines a comprehensive set of crew performance metrics, analyzes the relationship between motivational factors and crew performance, and identifies key situational/contextual factors that affect the relationship between motivation and performance. Multiple-source interview surveys identify factors that motivate construction crews, situational/contextual factors, and crew performance metrics. Correlation analysis is performed on field data to determine the relationship between motivational factors and crew performance. Hierarchical regression analysis is used to identify key moderators of the relationship between motivation and performance. This paper makes three major contributions: it develops a comprehensive set of construction crew performance metrics that relate not only to task performance, but also to contextual performance and counterproductive behavior; it reveals how

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motivational factors affect crew performance; and it provides a comprehensive list of key moderators of the relationship between construction crew motivation and performance.

Introduction

Construction project performance is a function of how efficiently resources, particularly labor, are utilized. Therefore, improving crew performance will significantly enhance project performance. Both crew motivation and the situation or context in which crew tasks are performed affect crew performance. Research in this area faces two challenges. The first is how to measure the factors affecting crew performance, such as motivational and situational/contextual factors. The second is how to determine the relationships that exist between motivational factors, situational/contextual factors, and crew performance.

Construction projects are executed in a dynamic environment that is influenced by several situational/contextual factors, such as those relating to task, labor, foreman, project characteristics, management, work-setting conditions, and resources. These factors will help or hinder the effect of motivation on crew performance. Thus, it is important to take into account situational/contextual factors when studying the impact of motivation on crew performance. The effect of situational/contextual factors on the relationship between crew motivation and performance has not been comprehensively investigated in previous construction literature. Some researchers have investigated a limited number of situational/contextual factors when studying motivation (Cox et al. 2006; Maloney and McFillen 1987; Šajeva 2007; Siriwardana and Ruwanpura 2012; Wang et al. 2016); however, these studies were not validated with field data and did not investigate the effects of situational/contextual factors on the relationship between crew motivation and performance.

This paper has three objectives: (1) to define a comprehensive set of crew performance metrics, including key performance indicators (KPIs) related not only to task performance (i.e., technical and job-specific performance), but also to contextual performance (i.e., discretionary and job-general performance) and counterproductive behavior; (2) to analyze the relationship between motivational factors and crew performance to reveal how motivational factors affect crew performance metrics; and (3) to investigate situational/contextual factors and to determine which of those factors have a moderating (i.e., interacting) effect on the relationship between crew motivation and performance.

Research Methodology

In this paper, motivational factors, their associated measures, and a comprehensive list of situational/contextual factors are identified based on past literature from both the construction and non-construction domains. A model of the relationship between motivational factors, situational/contextual factors, and crew performance is proposed, and each component of the model is described in detail. A novel, comprehensive set of construction crew performance metrics is defined, which includes KPIs related to task performance, contextual performance, and counterproductive behavior.

Two types of interview surveys, a supervisor survey and a craft survey, were designed and administered to a construction company actively involved in industrial projects in Canada. Factor analysis was performed on the survey data to confirm the validity of the identified measures of motivational factors. The definitions of motivational factors and their associated measures as well as the results of the factor analysis are presented in this paper. Based on the results of the factor analysis, field data were collected on crew motivational factors, situational/contextual factors, and crew performance metrics over the three-month timeline of an industrial construction project. Out of 11 crews active on the project, nine crews were working on work packages and two crews were involved in logistics and testing. All nine work package crews participated in the data collection.

Crew performance metrics were collected for all nine crews and for all 79 work packages of the project. For KPIs in the task performance category, actual project documents (e.g., time sheets, score cards, safety logs, change order logs, inspection test plans, schedule updates, tender documents, and cost estimates) were used to extract available task performance data. A total of 612 task performance data points were collected, which covered the task performance of all nine crews for all 79 work packages over 68 days of the project under study. For KPIs related to contextual performance and counterproductive behavior, multiple-source data collection was utilized, which accounts for both self-evaluation and supervisor evaluation. For each participating crew, self-evaluation forms (completed by crew members) and supervisor evaluation forms (completed by foremen) for contextual performance and counterproductive behavior were collected for all nine crews and for 17 work packages out of 79. For contextual performance and counterproductive behavior, a total of 153 data points were collected.

Motivational factors and situational/contextual factors were collected for all nine crews and for 17 work packages out of 79. The collected field data related to the 17 work packages were used for field data analysis because they included the full set of variables (i.e., motivational factors, situational/contextual factors, and crew performance metrics). Field data analysis was performed to investigate the relationship between crew motivational factors and crew performance and to identify key moderators of the relationship between crew motivation and performance. Both sets of analysis results are presented in this paper.

Proposed Model of the Relationship Between Motivational Factors, Situational/Contextual Factors, and Crew Performance

Both motivational factors and situational/contextual factors affect crew performance. Figure 1 shows the proposed model of the relationship between motivational factors, situational/contextual factors, and crew performance. Motivational factors are antecedent to crew motivation. Crew motivation is the predictor variable in the model. Situational/contextual factors are potential moderators of the relationship between crew motivation and performance. Crew performance is the dependent variable in the model.

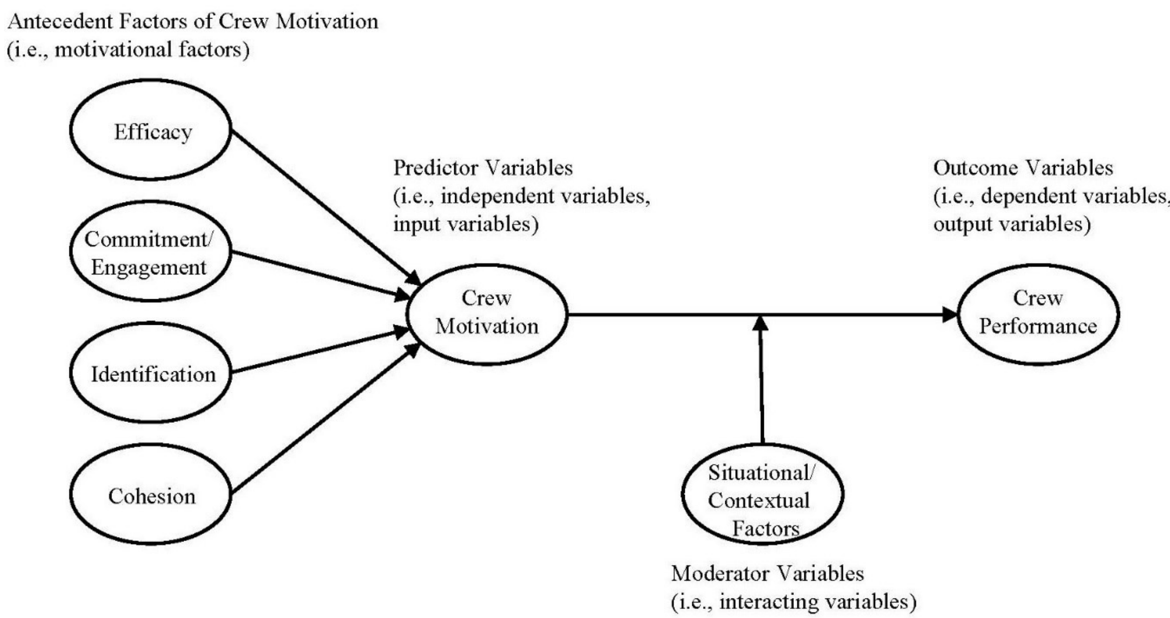

Figure 1. The relationship between motivational factors, situational/contextual factors, and crew performance.

The motivational factors are efficacy, commitment/engagement, identification, and cohesion, each of which operates at both individual and crew levels. Situational/contextual factors are factors related to the situation or context in which the work is being performed. Crew performance metrics are divided into three categories: task performance, contextual performance, and counterproductive behavior. The model's components are explained in detail in the following sections.

A moderator (i.e., interacting) variable is a factor that affects the strength or direction of the relationship between a predictor (i.e., an independent or input) variable and an outcome (i.e., a dependent or output) variable (Baron and Kenny 1986). In other words, a moderating effect is the interacting effect of two variables, where the effect of the predictor variable on the outcome variable depends on the level of the moderator variable (Frazier et al. 2004). Figure 1 shows the relationship of predictor, moderator, and outcome variables. For example, foreman leadership is a situational/contextual factor, and it has the potential to act as the moderator of the relationship between crew motivation and performance. If the moderating effect of foreman leadership exists, then we anticipate that crews supervised by foremen with better leadership skills will exhibit a stronger motivation-performance relationship. For such crews, increases in motivation lead to higher levels of crew performance compared to crews that are supervised by foremen who lack leadership skills. Therefore, it is important to investigate the moderators of the relationship between crew motivation and performance.

Defining Model Components

Motivational Factors

Past research on motivation has identified numerous individual-level work-motivation concepts (for a review of this research, see Diefendorff and Chandler 2011). More recent studies suggest there are some motivational concepts that influence crew motivation at both the individual and group (e.g., crew) levels (M. Raoufi and A. Robinson Fayek "Factors affecting construction crew motivation and performance: A framework for identification and assessment," submitted, *J. Constr. Eng. Manage.,* 2017). Following a review of literature on motivation in both the construction and non-construction domains, Raoufi and Fayek (2017) identified a major gap that exists in construction research on defining factors affecting crew motivation at both the individual and crew levels. Research in the non-construction domain identified four motivational concepts that operate at both the individual and group (e.g., crew) levels: efficacy (Bandura 1977), commitment/engagement (Meyer and Allen 1991), identification (Ashforth and Mael 1989), and cohesion (Beal et al. 2003). “Efficacy” is crew members’ judgments of their ability to organize and execute the courses of action required to achieve their top performance (Bandura 1977). “Commitment/engagement” is crew members’ emotional attachment to and involvement in the organization and/or a course of action (Meyer and Allen 1991). “Identification” is the emotional significance that members of a given group attach to their membership in that group (Ashforth and Mael 1989). “Cohesion” is the extent to which crew members are attracted to one another, whether they feel a bond with one another, and/or whether the crew members “stick together” as a unit (Beal et al. 2003). As a single measure alone cannot perfectly represent a motivational factor, researchers suggest using at least three measures for each motivational factor (Xiong et al. 2015). For example, to measure efficacy at the crew level (a motivational factor), Raoufi and Fayek (2017) suggest using three measures: “crew confidence in ability to perform tasks effectively,” “crew confidence in ability to perform difficult tasks,” and “crew ability to concentrate on performing tasks.” In this paper, for each of the motivational factors shown in Figure 1, at least three motivational measures are identified based on past research (Raoufi and Fayek 2017). Seventeen motivational measures are identified for motivational factors at the individual level and 16 motivational measures are identified for motivational factors at the crew level (see Tables 4 and 5 in the following sections for the list of identified motivational measures).

Motivational factors and measures were gathered using surveys and during field data collection. The sources of data were two surveys, supervisor and craft surveys, and interviews with foremen and crew members during field data collection. Factor analysis was performed on the survey data to check the validity and reliability of the motivational measures. Following factor analysis, field data were collected. For each day of field data collection, project staff sent the daily plan to the data collector. Based on the daily plan, the data collector randomly selected the crews to be studied from the available crews working that day. For each selected crew, randomly selected members performed a self-evaluation on their individual-level motivational factors. The supervisor of the responding crew evaluated the crew-level motivational factors. Self-evaluation was used to determine the values of individual-level motivational factors while supervisor evaluation was used to determine the values of crew-level motivational factors.

Situational/Contextual Factors

Situational/contextual factors might affect the relationship between crew motivation and performance. Therefore, in addition to motivational factors, it is important to take into account situational/contextual factors when studying the impact of motivation on crew performance. On construction projects, for example, situational/contextual factors can be task-related (e.g. task design), labor-related (e.g., the functional skills of the crew), foreman-related (e.g., leadership skills), project characteristics (e.g., work shifts), management-related (e.g., project management practices), work-setting conditions (e.g., weather conditions), and resources (e.g., tools, equipment, material) (AbouRizk et al. 2001; Dai et al. 2009; Fayek and Oduba 2005; Goddard et al. 2004; Knight and Fayek 2000; Liberda et al. 2003; Tsehayae and Fayek 2014). In this paper, a total of 129 situational/contextual factors in eight categories are identified. Three categories of situational/contextual factors are at the crew level (i.e., task-related, labor-related, and foreman-related) and five categories of situational/contextual factors are at the project level (i.e., project characteristics, management-related, work-setting conditions, resources, and safety).

Situational/contextual factors from all categories were collected in the field for each participating crew on each day of field data collection. The sources of data collection for situational/contextual factors were interviews with project personnel, including crew members, foremen, field supervisors, and project managers; observations by data collectors on the work packages of the project; project databases and documents such as project safety logs; and external sources such as government databases (e.g., databases for weather data). Table 1 shows a sample data collection form for situational/contextual factors.

Table 1. Situational/contextual factors: Task-related.

Situational/contextual factors	Scale of measure	Sub-factors	Range of values
Task type	Categorical		1. Civil 2. Mechanical 3. Electrical 4. Instrumentation
Task size	Real number (Quantity)		$\mathbb{R}^+$
Task complexity	Five-point rating scale	• Number of subtasks • Number of alternatives to do the task • Unknown means	(1) Very low to (5) Very high
Task repetition	Percentage (% of identical tasks in work package over total tasks in work package)		[0%, 100%]
Task interruption and disruption	Integer (Number of interruption and disruption events per day)		$\mathbb{Z}^+$

Crew Performance Metrics

Construction projects have traditionally been evaluated in terms of time, cost, and quality (Kagioglou et al. 2001). However, these categories of performance measures have been shown to be insufficient (Ward et al. 1991). Past research has demonstrated that other performance measures, such as productivity, are also related to the success of a project (Tsehayae and Fayek 2016). However, there are other performance measures that impact project success, such as the quality of the relationships between crew members on a project (Bassioni et al. 2004). Other aspects of performance, such as contextual performance and counterproductive behavior, are important for defining the performance metrics of a construction crew, as they are at the discretion of workers and are thus more likely to be affected by workers' motivation. In this study, a broader perspective on crew performance is employed by taking into consideration more generic models of performance developed outside the construction literature. For example, many of these generic models supplement a narrow "technical-task" perspective of performance with behaviors that support technical activities and contribute to overall effectiveness (e.g., helping others, working with enthusiasm, not engaging in counterproductive behavior). In his seminal paper, Campbell (1990) proposed that the performance domain for any job involves some or all of eight generic dimensions: job-specific technical task proficiency, non-job-specific task proficiency, communication proficiency, demonstrating effort, maintaining personal discipline, facilitating peer and team performance, supervision, and management. While the first six dimensions tend to characterize all jobs, the latter two dimensions tend to be emphasized in jobs with leadership or management duties. Borman and Motowidlo (1997) proposed a model of performance that made a distinction between behaviors that were technical and job-specific in nature (i.e., task performance), and those that tended to be discretionary and job-general (i.e., contextual performance). Contextual performance includes behaviors that affect the social context in which the technical activities occur (also referred to by Organ [1988] as organizational citizenship behavior). The notion of contextual performance (e.g., helping, compliance) is particularly relevant for construction contexts given the interdependent nature of the work (e.g., crew members persisting to complete technical tasks, volunteering, helping and cooperating with other crew members, following procedures and rules, and supporting crew objectives).

In this paper, the following crew performance metrics were identified: task performance, contextual performance, and counterproductive behavior. Task performance consists of seven categories: cost performance, schedule performance, change performance, quality performance, safety performance, productivity performance, and satisfaction performance. Contextual performance consists of three categories: personal support, organizational support, and conscientious initiative. Counterproductive behavior consists of two categories: interpersonal deviance and organizational deviance. Each category of crew performance metrics has several KPIs. A total of 12 different crew performance metrics categories, consisting of 55 KPIs, have been identified from previous research (Bennett and Robinson 2000; Borman et al. 2001; Chan and Chan 2004; Gruys and Sackett 2003; Omar and Fayek 2016; Organ 1988; Podgórski 2015; Rankin et al. 2008; Wildman et al. 2011). Table 2 shows the identified crew performance metrics categories and the KPIs in each category. Crew performance data were collected for all crews and for all work packages. For task performance, actual project documents (e.g., time sheets, score cards, safety logs, change order logs, inspection test plans, schedule updates, tender documents, and cost estimates) were used to extract available crew performance data. Then, KPIs related to task performance were calculated for all crews. Table 3 shows a sample of some KPIs in the cost performance category. For KPIs related to contextual performance and counterproductive behavior, multiple-source data collection was utilized, which accounts for both self-evaluation and supervisor evaluation. For each participating crew, self-evaluation forms for contextual performance and counterproductive behavior were completed by crew members. The mean of the crew members' self-evaluations is equal to the crew members' overall evaluation of crew contextual performance and counterproductive behavior. For the same crew, supervisor evaluation forms were completed by the foreman to evaluate crew contextual performance and counterproductive behavior. Following data collection, the mean of the crew members' overall evaluation and the foreman evaluation was calculated. In calculating each KPI for the two crew performance categories (i.e., contextual performance and counterproductive behavior), equal weight was assumed for the crew members' overall evaluation and for the foreman evaluation.

Table 2. Crew performance metrics and KPIs: Fayek and Raoufi taxonomy.

Crew performance metrics	Crew performance metrics category	No. of KPIs	KPIs
Task performance	Cost performance indicators	8	Work package cost growth, work package budget factor, work package indirect cost factor, work package direct cost factor, work package cost predictability, work package net variation over final cost, cost per unit at completion, cost for defects warranty
	Schedule performance indicators	5	Work package schedule factor, work package schedule growth, time predictability (work package), time variance (work package), time per unit at completion
	Change performance indicators	6	Total change cost factor, cost for change demand, cost for change supply, time for defects warranty, time for change demand, time for change supply
	Quality performance indicators	4	Work package rework cost factor, work package rework time factor, work package rework index, quality issues-available for use
	Safety performance indicators	5	Lost time rate, lost time frequency, reported incidents rate, first aid frequency rate, near miss incident frequency rate
	Productivity performance indicators	5	Work package productivity factor (physical work), work package productivity factor (cost), work package productivity index, work package absenteeism rate, work package productivity factor (pf)
	Satisfaction performance indicators	1	Overall performance satisfaction
Contextual performance	Personal support	4	Helping, cooperating, courtesy, motivating
	Organizational support	3	Representing, loyalty, compliance
	Conscientious initiative	3	Persistence, initiative, self-development
Counterproductive behavior	Interpersonal deviance	4	Inappropriate verbal actions, unsafe behavior, inappropriate physical actions, alcohol consumption or drug use
	Organizational deviance	7	Poor attendance, misuse of time, misuse of resources, misuse of information, poor quality work, destruction of property, theft and related behavior
	Total	55	

Table 3. Task performance: Cost performance indicators.

KPI No.	KPI name	KPI definition	KPI formula	KPI threshold
1.1.1	Work package cost growth	The variance between the actual total work package cost and total work package estimated cost at tender stage, expressed as a ratio of total work package estimated cost at tender stage	$\frac{(actual\ total\ work\ package\ cost - total\ work\ package\ estimated\ cost\ at\ tender\ stage)}{total\ work\ package\ estimated\ cost\ at\ tender\ stage}$	<0 Desirable Value =0 Planned Value >0 Undesirable Value
1.1.5	Work package cost predictability	The variance between the actual total work package cost and total work package estimated cost at tender stage, expressed as a percentage of the actual total work package cost.	$\frac{(actual\ total\ work\ package\ cost - total\ work\ package\ estimated\ cost\ at\ tender\ stage)}{actual\ total\ work\ package\ cost} \times 100$	<0% Desirable Value =0% Planned Value >0% Undesirable Value
1.1.6	Work package net variation over final cost	The ratio between the net value of variations in work package cost based on original work package scope and the total work package estimated cost at tender stage, expressed as a percentage.	$\frac{net\ value\ of\ variations\ in\ work\ package\ cost}{total\ work\ package\ estimated\ cost\ at\ tender\ stage} \times 100$	=0% Desirable Value >0% Undesirable Value

Factor Analysis of Motivational Factors at the Individual and Crew Levels

Two types of interview surveys, a supervisor survey and a craft survey, were administered to collect data on the factors affecting crew motivation and performance. Factor analysis was performed for all motivational factors at both the individual and crew levels as well as for their associated measures to check the validity of the identified measures for each factor. Construct validity (i.e., the validity of the measures of a factor) is necessary for reliable theory development (Xiong et al. 2015). Construct validity not only reveals whether the measures within a construct are consistent in measuring the same thing, but it also reveals whether the measures of a construct are distinct from the measures of different constructs (Bagozzi and Yi 2012). There are two common tests for construct validity: convergent validity and discriminant validity. Convergent validity assesses whether the measures of a factor are a good representation of that factor by testing the degree of positive correlation of one measure with other measures within the same factor. Discriminant validity tests whether a factor is truly different from other factors (Xiong et al. 2015). A very common method of testing construct validity, both convergent validity and discriminant validity, is confirmatory factor analysis (CFA). CFA measures the consistency between the measures of a factor and the factor they are measuring, as well as the distinction of the measures of a factor with the measures of other factors. In this paper, CFA is performed to check if the identified motivational measures are valid for measuring the motivational factors they represent. IBM SPSS AMOS® was used to perform CFA, and the results of factor loading (i.e., the amount of contribution of each measure to its corresponding factor) are presented in Tables 4 and 5.

Table 4. Confirmatory factor analysis of motivational factors at the crew level.

Measure ID	Motivational measures at the crew-level	Standardized factor loadings			
		Factor 1: Efficacy	Factor 2: Commitment/ engagement	Factor 3: Identification	Factor 4: Cohesion
Efficacy 1	Crew confidence in ability to perform tasks effectively	0.662	—	—	—
Efficacy 2	Crew confidence in ability to perform difficult tasks	0.918	—	—	—
Efficacy 3	Crew ability to concentrate on performing tasks	0.664	—	—	—
Commit./Engage. 1	Crew members are very happy to spend rest of career with the organization	—	0.546	—	—
Commit./Engage. 2	Crew members see the organization's problems as own	—	0.748	—	—
Commit./Engage. 3	Crew's sense of "belonging" to the organization	—	0.919	—	—
Commit./Engage. 4	Crew's emotional attachment to the organization	—	0.772	—	—
Commit./Engage. 5	Crew members feel like "part of the family" at the organization	—	0.869	—	—
Commit./Engage. 6	The organization has personal meaning to the crew	—	0.772	—	—
Identification 1	Crew members feel proud to be part of the crew	—	—	0.785	—
Identification 2	Crew members' identification with the other members of the crew	—	—	0.798	—
Identification 3	Crew members would like to continue working with the crew	—	—	0.571	—
Identification 4	Crew members' emotional attachment to the crew	—	—	0.739	—
Cohesion 1	Crew members get along well together	—	—	—	0.596
Cohesion 2	Defending each other from criticism	—	—	—	0.500
Cohesion 3	Crew members are close	—	—	—	0.824

Table 5. Confirmatory factor analysis of motivational factors at the individual level.

Measure ID	Motivational measures at the individual-level	Standardized factor loadings			
		Factor 1: Efficacy	Factor 2: Commitment/ engagement	Factor 3: Identification	Factor 4: Cohesion
Efficacy 1	Self-confidence in ability to perform tasks effectively	0.754	—	—	—
Efficacy 2	Self-confidence in ability to perform difficult tasks	0.938	—	—	—
Efficacy 3	Ability to concentrate on performing tasks	0.603	—	—	—
Commit./Engage. 1	Seeing the organization's problems as own	—	0.580	—	—
Commit./Engage. 2	Sense of "belonging" to the organization	—	0.639	—	—
Commit./Engage. 3	Emotional attachment to the organization	—	0.935	—	—
Commit./Engage. 4	Feeling like "part of the family" at the organization	—	0.690	—	—
Commit./Engage. 5	The organization has personal meaning	—	0.965	—	—
Identification 1	Feeling proud to be part of the crew	—	—	0.892	—
Identification 2	Identification with the other members of the crew	—	—	0.836	—
Identification 3	Would like to continue working with the crew	—	—	0.780	—
Identification 4	Emotional attachment to the crew	—	—	0.944	—
Cohesion 1	Choose to stay in the crew	—	—	—	0.636
Cohesion 2	Feel like a part of the crew	—	—	—	0.838
Cohesion 3	Like to be with crew members	—	—	—	0.790
Cohesion 4	Get along with other crew members	—	—	—	0.669
Cohesion 5	Enjoy belonging to the crew	—	—	—	0.901

Researchers suggest that measures with a standardized factor loading of less than 0.5 be deleted (Xiong et al. 2014). The results of the CFA suggest a satisfactory construct validity (convergent and discriminant validity). Each factor is loaded just on its own measures (e.g., efficacy is loaded on efficacy measures), and no standardized factor loadings are less than 0.5, indicating a convergent validity. No factor is loaded on the measures of other factors (e.g., efficacy is not loaded on any commitment/engagement measures, identification measures, or cohesion measures), indicating a discriminant validity. After performing CFA, the results, such as the loadings shown in Tables 4 and 5, are used to perform reliability tests to check the reliability of the identified measures of motivational factors. Composite reliability (*CR*) is calculated for each motivational factor using Equation 1 (Raykov 1997; Xiong et al. 2015).

$$CR_i = \frac{\left(\sum_{k=1}^{n_i} L_{ik}\right)^2}{\left(\sum_{k=1}^{n_i} L_{ik}\right)^2 + \left(\sum_{k=1}^{n_i} e_{ik}\right)}, \tag{1}$$

where i refers to factor i; k refers to measure k; n_i is the number of measures for factor i; L_{ik} refers to the factor loading of measure k of factor i; and e_{ik} refers to the error variance of measure k of factor i. The rule of thumb for reliability in the identified measures of a factor is that a *CR* of 0.7 or higher suggests a satisfactory reliability (Bagozzi and Yi 2012). The calculated *CRs* were as follows: efficacy–individual level was 0.99, commitment/engagement–individual level was 0.76, identification–individual level was 0.93, cohesion–individual level was 0.90, efficacy–crew level was 0.87, commitment/engagement–crew level was 0.83, identification–crew level was 0.81, and cohesion–crew level was 0.72. These results indicate a satisfactory reliability in the identified measures of the motivational factors.

Factor loadings are used to calculate the weighted score of each factor (Wang et al. 2016). In this paper, the weight (w_{ij}) of each motivational measure for a given motivational factor is computed using Equation 2.

$$w_{ij} = \frac{L_{ij}}{\sum_{k=1}^{n_i} L_{ik}}, \quad (2)$$

where i refers to factor i; j refers to measure j; n_i is the number of measures for factor i; L_{ik} refers to factor loading of measure k of factor i; and L_{ij} refers to the factor loading of measure j of factor i. For example, using Equation 2, the calculated matrix of weights for factor 1 (i.e., efficacy at the crew level) are shown in Equation 3.

$$W_1 = [w_{11} \quad w_{12} \quad w_{13}] = [0.295 \quad 0.409 \quad 0.296] \quad (3)$$

Next, the weighted score (S) of each motivational factor i is computed using Equation 4.

$$S_i = \sum_{j=1}^{n_i} w_{ij}.R_j, \quad (4)$$

where w_{ij} is the weight of measure j in calculating the weighted score of factor i; R_j is the mean rating value of measure j; and n_i is the number of measures for factor i. For example, using Equation 3 for the weights of factor 1 (i.e., efficacy at the crew level) and considering mean rating values of 6.51, 6.49, and 6.32 on a 1 to 7 rating scale for the rating of the existence of each identified efficacy measure, the weighted score of factor 1 is calculated as shown in Equation 5.

$$S_{\text{Efficacy−Crew Level}} = [w_{11} \quad w_{12} \quad w_{13}].\begin{bmatrix} R_1 \\ R_2 \\ R_3 \end{bmatrix} = [0.295 \quad 0.409 \quad 0.296].\begin{bmatrix} 6.51 \\ 6.49 \\ 6.32 \end{bmatrix} = 6.45 \quad (5)$$

Following factor analysis on the survey data and after the confirmation of the validity and reliability of the measures of motivational factors, field data collection forms were designed using the validated measures. Field data collection was performed to collect crew motivational factors, situational/contextual factors, and crew performance metrics in an actual project setting. For each day of field data collection, project staff sent the daily plan to the data collector. Based on the daily plan, the data collector randomly selected the crews to be studied from the available crews working that day. For each selected crew, randomly selected members of the crew performed a self-evaluation and the supervisor of the crew performed a supervisor evaluation. Self-evaluation is used to determine the values of individual-level motivational factors, while both self-evaluation and supervisor evaluation are used to determine the values of crew-level motivational factors. Each motivational factor was evaluated on a 1 to 5 rating scale for each crew on the project. To produce consistent evaluations among different supervisors, the validated measures of each motivational factor, based on the results of the performed factor analysis, were included in the field data collection forms. For example, to measure efficacy at the crew level, three identified and validated measures, "crew confidence in ability to perform tasks effectively," "crew confidence in ability to perform difficult tasks," and "crew ability to concentrate on performing tasks," were added to the field data collection form as sub-factors of efficacy. Then, the respondents rated efficacy from 1 (least desirable) to 5 (most desirable) with respect to the provided measures in the field data collection form. Based on the collected data, individual-level and crew-level motivational factors were calculated for each crew. The mean values of the motivational factors for all participating crews are shown in Figure 2. The values in Figure 2 are on a scale of 1 to 5, with 1 representing the least desirable value and 5 representing the most desirable value.

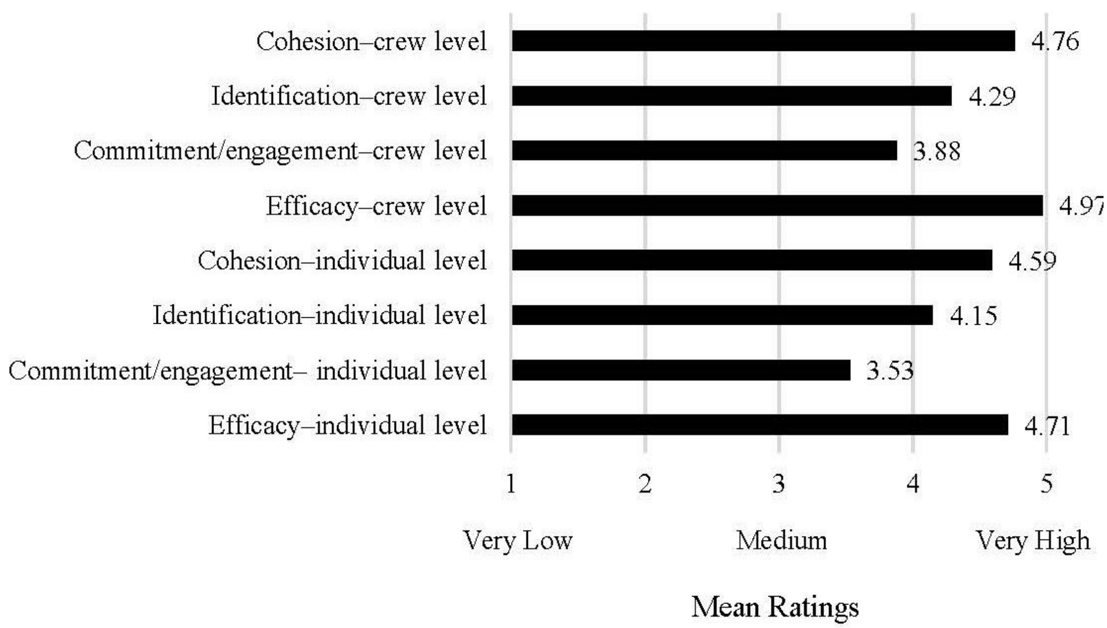

Figure 2. Mean values of motivational factors (1–5 rating scale).

The results in Figure 2 indicate that the most satisfied motivational factor (i.e., the factor closest to the most desirable value) among participating crew was crew efficacy at the crew level and crew cohesion at the crew level. The least satisfied motivational factor (i.e., the factor farthest from the most desirable value) was commitment/engagement at the individual level. Moreover, the values related to crew-level assessments of motivational factors were higher than the values of individual-level assessments of motivational factors. These findings are in agreement with the results of other studies in non-construction fields, which indicate that when working in a group (e.g., a crew), the overall motivation of the group (i.e., crew-level motivation) is greater than the motivation of its individual members (i.e., the mean value of the individual-level motivation of crew members). This phenomenon may be attributed to the interactions of individuals within the crew. Therefore, policies that promote interactions among crew members (e.g., more interactive site orientations, safety meetings, or daily meetings) may help improve crew motivation.

Relationship Between Motivational Factors and Crew Performance

Correlation analysis was performed to assess the relationship between motivational factors and crew performance metrics. Pearson correlation analysis is the most common technique for correlation analysis (Bobko 2001). The Pearson correlation coefficient (r) is used in correlation analysis to measure the relationship between independent variables (e.g., motivational factors) and dependent variables (e.g., crew performance metrics). The Pearson correlation coefficient determines two characteristics of the relationships between two variables: the direction of the relationship and the strength of the relationship. The direction of the relationship between two variables can be positive or negative. A positive relationship shows that the two variables change in the same direction (i.e., increasing simultaneously or decreasing simultaneously), while a negative relationship shows that the two variables change in opposite directions (i.e., if one variable increases the other variable will decrease). The magnitude of the relationship between the two variables is determined by the value of the Pearson correlation coefficient. The Pearson correlation coefficient varies between -1 and 1. Based on the value of the Pearson correlation coefficient, the magnitude of the relationship between a pair of variables may fall into one of four categories: no correlation for $r < 0.1$, weak correlation for $0.1 \leq r < 0.3$, moderate correlation for $0.3 \leq r < 0.5$, and strong correlation for $r \geq 0.5$ (Cohen et al. 2013).

To calculate crew performance metrics for correlation analysis, each crew performance metric (i.e., task performance, contextual performance, or counterproductive behavior) is calculated based on the mean of its metrics categories. For example, task performance is calculated as the mean of the following metrics categories: cost performance, schedule performance, change performance, quality performance, safety performance, productivity performance, and satisfaction performance. This approach ensures equal weighting between task performance categories and ensures that the difference in the number of identified KPIs in each task performance category does not affect the mean task performance. Since each metrics category has different KPIs with different ranges of values, the KPIs in that category are first normalized by dividing each KPI by its maximum value, to achieve a value between 0 (undesirable value) and 1 (desirable value). For example, for the KPIs that are evaluated on a 1 to 7 rating scale, the maximum value is 7. For KPIs that are evaluated using mathematical formulations (i.e., KPIs in the task performance category), the maximum value is the maximum of that KPI for all 79 work packages. Then, the mean of the normalized KPIs is calculated for each crew performance metrics category. For example, the crew performance metrics category of schedule performance is calculated based on the mean of the following normalized values: work package schedule factor, work package schedule growth, time predictability (work package), time variance (work package), and time per unit at completion. The results of the correlation analysis between motivational factors and crew performance metrics are presented in Table 6, including the means, standard deviations, and intercorrelations among variables.

The means and standard deviations for motivational factors are calculated based on the collected field data. The results shown in Table 6 indicate that all motivational factors have a weak positive relationship ($0.1 \leq r < 0.3$) with task performance, a moderate ($0.3 \leq r < 0.5$) to strong ($r \geq 0.5$) positive relationship with contextual performance, and a moderate ($-0.5 \leq r < -0.3$) to strong ($r \leq -0.5$) negative relationship with counterproductive behavior. For each pair of variables, in addition to the correlation coefficient, the significance of the relationship between the two variables is tested and the *p*-values are calculated. Table 6 shows which relationships are significant at $p<0.01$ and $p<0.05$. Cohesion–individual level (r=0.540, p=0.025), efficacy–crew level (r=0.497, p=0.042) and commitment/engagement–crew level (r=0.497, p=0.042) have a significant relationship ($p<0.05$) with contextual performance. Cohesion–individual level (r=-0.572, p=0.016) and identification–crew level (r=-0.570, p=0.017) have a significant relationship ($p<0.05$) with counterproductive behavior. Commitment/engagement–individual level (r=-0.744, p=0.001), efficacy–crew level (r=-0.674, p=0.003), commitment/engagement–crew level (r=-0.674, p=0.003), and cohesion–crew level (r=-0.750, p=0.001) have a significant relationship ($p<0.01$) with counterproductive behavior. These findings indicate that increases in cohesion at the individual level and/or efficacy and/or commitment/engagement at the crew level improve crew contextual performance. Increases in efficacy and/or cohesion at the individual level and/or increases in any/all motivational factors at the crew level reduce crew counterproductive behavior. The results also show a weak positive correlation between motivational factors and task

Table 6. Correlation analysis of motivational factors with crew performance metrics.

Variables	Mean	Standard deviation	1	2	3	4	5	6	7	8	9	10	11
1. Efficacy–individual level	4.706	0.398	1.000										
2. Commitment/engagement–individual level	3.529	0.800	0.127	1.000									
3. Identification–individual level	4.147	0.786	0.647[b]	0.266	1.000								
4. Cohesion–individual level	4.588	0.404	0.463	0.668[b]	0.546[a]	1.000							
5. Efficacy–crew level	4.971	0.121	0.457	0.493[a]	0.048	0.375	1.000						
6. Commitment/engagement–crew level	3.882	0.485	0.457	0.573[a]	0.376	0.375	0.469	1.000					
7. Identification–crew level	4.294	0.751	0.465	0.453	0.610[b]	0.372	0.444	0.701[b]	1.000				
8. Cohesion–crew level	4.765	0.400	0.225	0.707[b]	0.316	0.619[b]	0.493[a]	0.654[b]	0.557[a]	1.000			
9. Task performance	0.828	0.027	0.127	0.143	0.116	0.135	0.166	0.221	0.124	0.167	1.000		
10. Contextual performance	0.770	0.062	0.469	0.415	0.326	0.540[a]	0.497[a]	0.497[a]	0.434	0.317	-0.222	1.000	
11. Counterproductive behavior	0.200	0.074	-0.410	-0.744[b]	-0.309	-0.572[a]	-0.674[b]	-0.674[b]	-0.570[a]	-0.750[b]	-0.031	-0.671[b]	1.000

[a] Correlation is significant at p<0.05.
[b] Correlation is significant at p<0.01.

performance, but the correlations are not significant (i.e., there is not enough evidence that motivational factors and task performance are correlated).

As shown in Table 6, the correlations of crew-level motivational factors with crew performance metrics are higher than those of individual-level motivational factors with crew performance metrics, indicating that the interactions of individuals with each other in a group have a greater impact on crew motivation than any one individual. The results of the correlation analysis on the collected field data confirm the findings based on the factor analysis of the survey data that has previously been discussed. In terms of intercorrelations between performance metrics, only contextual performance is significantly correlated with counterproductive behavior (r = -0.671, p=0.003). The correlation is high but not perfectly correlated (i.e., $r < 1.00$), suggesting that these performance dimensions (i.e., contextual performance and counterproductive behavior) are distinct dimensions of performance. Although the strength of the correlation between contextual performance and counterproductive behavior differs amongst studies in the non-construction domain, the correlations are significant, which is in agreement with the results of this study (Dalal 2005; Devonish and Greenidge 2010).

Crew performance is calculated as the mean of the crew performance metrics (i.e., task performance, contextual performance, or counterproductive behavior). Table 7 shows the correlation between motivational factors and crew performance. The results indicate that almost all motivational factors (except identification–individual level) have a strong positive relationship ($r \geq 0.5$) with crew performance. The strongest relationship is related to commitment/engagement (r=0.694 at the crew level and r=0.678 at the individual level), followed by cohesion (r=0.638 at the crew level and r=0.636 at the individual level), and then efficacy (r=0.682 at the crew level and r=0.503 at the individual level). The weakest relationship was observed for identification

(r=0.580 at the crew level and r=0.370 at the individual level). The significance of the relationship between variables was tested and the p-values calculated; the results suggest there is a significant relationship between almost all the motivational factors (except identification–individual level) and crew performance ($p<0.05$ for efficacy–individual level and identification–crew level, $p<0.01$ for commitment/engagement–individual level, cohesion–individual level, efficacy–crew level, commitment/engagement–crew level, and cohesion–crew level).

Table 7. Correlation analysis of motivational factors with crew performance.

Variables	Correlation (r) to crew performance	p-value
1. Efficacy–individual level	0.503[a]	0.040
2. Commitment/engagement–individual level	0.678[b]	0.003
3. Identification–individual level	0.370	0.144
4. Cohesion–individual level	0.636[b]	0.006
5. Efficacy–crew level	0.682[b]	0.003
6. Commitment/engagement–crew level	0.694[b]	0.002
7. Identification–crew level	0.580[a]	0.015
8. Cohesion–crew level	0.638[b]	0.006

[a] Correlation is significant at $p<0.05$.
[b] Correlation is significant at $p<0.01$.

Identifying Key Moderators of the Relationship Between Crew Motivation and Performance

Situational/contextual factors have the potential to act as moderators of the relationship between crew motivation and performance. However, not all situational/contextual factors are moderators of this relationship; therefore, it is important to identify which situational/contextual factors act as moderators of the relationship between crew motivation and performance. Statistical analysis (i.e., hierarchical multiple regression) was conducted on the field data to test the moderating effect of each of the 129 identified situational/contextual factors on the relationship between crew motivation and performance. Hierarchical multiple regression is commonly used to test moderating effects for both categorical and numerical data (Cohen et al. 2013; Frazier et al. 2004).

IBM SPSS Statistics was used to perform hierarchical regression analysis. To illustrate the analysis, a sample is given of hierarchical regression analysis for investigating the moderating effect of one of the situational/contextual variables (i.e., congestion) on the relationship between crew motivation and performance. Crew motivation is the predictor variable and is calculated as the mean of motivational factors, congestion is the possible moderator variable and is a situational factor, and crew performance is the outcome variable (see Figure 1). First, the predictor variable (i.e., crew motivation) and the moderator variable (i.e., congestion) are standardized. Standardization of a variable involves transforming that variable into another variable (called a *z*-scored variable) so that it has a mean of 0 and a standard deviation of 1. Both *z*-scored crew motivation and *z*-scored congestion are calculated. Second, the interaction term, which is the product of the *z*-scored predictor and the *z*-scored moderator, is calculated. The interaction term between crew motivation and congestion is calculated as *z*-scored crew motivation multiplied by *z*-scored congestion. Finally, two regression models are tested. The first model considers crew motivation and congestion as predictors of crew performance. The second model considers crew motivation, congestion, and the interaction term as predictors of crew performance. The moderating effect of congestion on the relationship between crew motivation and performance exists if there are two conditions. First, there must be a significant relationship between the interaction term (crew motivation × congestion) and crew performance. Second, the R^2 of the second model (i.e., the model with the interaction term) must be higher than the R^2 of the first model (i.e., the model without the interaction term). The results of the hierarchical multiple regression analysis are provided in Table 8.

Table 8. Results of hierarchical multiple regression on the moderating effect of congestion on the relationship between crew motivation and performance.

Model No.	Model variables	Unstandardized regression coefficients		Standardized regression coefficients	Significance	Correlation to crew performance	Model fit
		B	Std. Error	β	p-value	r	R^2
1	Crew motivation (z score)	0.019	0.005	0.46	0.002	0.78[b]	0.83
	Congestion (z score)	-0.025	0.005	-0.59	0.000	-0.84[b]	
2	Crew motivation (z score)	0.010	0.004	0.23	0.021	0.78[a]	0.94
	Congestion (z score)	-0.021	0.003	-0.51	0.000	-0.84[b]	
	Crew motivation × congestion (z score)	0.012	0.003	0.42	0.000	0.82[b]	

[a] Correlation is significant at p<0.05.

[b] Correlation is significant at p<0.01.

In Table 8, B is the unstandardized regression coefficient and β is the standardized regression coefficient. β is the regression coefficient that is standardized so that the predictor variable (i.e., crew motivation), the moderator variable (i.e., congestion), and the outcome variable (i.e., crew performance) have variances of 1. Standardization of regression coefficients helps with the comparison of regression coefficients of variables that have different ranges (i.e., comparing the effects of different moderators). Standard error is the error associated with the calculated B. The p-value is the significance associated with the regression coefficients (either B or β). The r is the correlation coefficient of each variable to crew performance. The R^2 is the coefficient of determination representing the fit of each regression model. The adjusted R^2, a modified version of R^2 that considers the number of variables in the model, is used in this paper.

The unstandardized regression coefficient for crew motivation is 0.019 (p<0.01), indicating that there is a significant positive relationship between crew motivation and performance. The unstandardized regression coefficient for congestion is -0.025 (p<0.01), meaning that there is a significant negative relationship between congestion and crew performance. The unstandardized regression coefficient for the interaction term (i.e., crew motivation × congestion) is 0.012

(p<0.01), indicating that there is a significant positive relationship between the interaction term and crew performance. The R^2 for the first model (the model without the interaction term) is 0.83, and the R^2 for the second model (the model with the interaction term) is 0.94. Therefore, the R^2 change (ΔR^2) associated with the interaction term is 11%. ΔR^2 indicates the amount of additional variance in crew performance explained by the interaction term over the variance explained by the effects of crew motivation and congestion alone. In other words, ΔR^2 indicates the goodness of fit of the model with the interaction term compared to the model without the interaction term. The interaction between congestion and crew motivation explains an additional 11% of the variance in crew performance over the variance explained by the effects of crew motivation and congestion alone. This means that congestion moderated the effect of crew motivation on crew performance.

In addition to the above discussions on the strength of the relationships, the direction of the relationships is also important. In Table 8, the unstandardized regression coefficient (*B*) may have either a positive sign or a negative sign. For example, for crew motivation *B* is positive, and for congestion *B* is negative. This indicates that crew motivation has a positive effect on crew performance, while congestion has a negative effect on crew performance. For the interaction term (crew motivation × congestion), *B* is positive indicating that the interaction term has a positive effect on crew performance.

To better illustrate the moderating effect, a common practice suggested by Cohen et al. (2003) is to plot the predictor and moderator variables against the outcome variable at four points, for example, *low* crew motivation and *low* congestion, *high* crew motivation and *low* congestion, *high* crew motivation and *low* congestion, and *high* crew motivation and *high* congestion. The *low* is represented by the mean minus 1 *SD* (i.e., standard deviation) and the *high* is represented by the mean plus 1 *SD* for each of the predictor and moderator variables. The moderating effect exists when the slopes of the lines representing the *low* and *high* for the variable, investigated for moderating effect (i.e., congestion), differ from each other in the plot, where the *x*-axis represents the predictor variable and the *y*-axis represents the outcome variable (Frazier et al. 2004). Figure 3 shows the plot of the interaction of crew motivation and congestion. Crew motivation (the predictor variable) and congestion (the moderator variable) are plotted against crew performance (the outcome variable). As shown in Figure 3, the slopes of the lines representing *low* congestion and *high* congestion differ from each other, indicating the moderating effect of congestion on the relationship between crew motivation and performance.

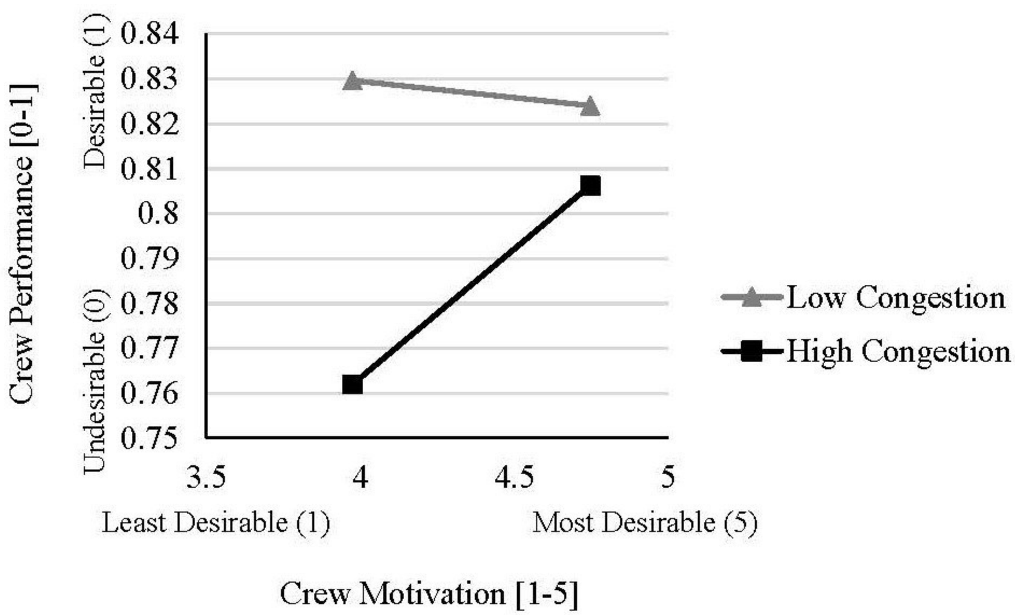

Figure 3. Plot of the interaction of crew motivation and congestion.

Hierarchical regression analysis was performed for each of the 129 situational/contextual factors and for crew motivation. Then, the moderators of the relationship between motivation and performance were identified. Table 9 lists the identified moderators of the relationship between crew motivation and performance. Fourteen moderators were identified, and the standardized regression coefficients, *p*-values, correlations of each moderator with crew performance, and the

ΔR^2 associated with the interaction term are presented in Table 9. As shown in Table 9, 14 situational/contextual factors moderate the effect of crew motivation on crew performance. The first observation from these results is related to the magnitude of the standardized regression coefficients (β). The factors with higher absolute values of β have a stronger moderating effect on the relationship between crew motivation and performance. The highest absolute value of the standardized regression coefficient (β) associated with the interaction term is associated with building trust (-0.88, p=0.040), indicating that building trust has the strongest moderating effect on the relationship between crew motivation and performance compared to other moderators.

The second observation from the results in Table 9 is related to the sign (either positive or negative) of the standardized regression coefficient (β), which provides information on the direction of the relationship between the interaction term and crew performance. In Table 9, β is positive for the interaction terms of two moderators: crew size and congestion. This result indicates that the interaction of either of these two moderators with crew motivation has a positive effect on the crew performance. β is negative for the interaction terms of 12 moderators: task type, task repetition, visibility of outcome, foreman knowledge, performance monitoring, communication, goal setting, working relationship, building trust, project time management, project cost management, and location of facilities. This result indicates that the interaction of any of these 12 moderators with crew motivation has a negative effect on crew performance.

The third observation from the results in Table 9 is related to ΔR^2, which indicates the amount of additional variance in crew performance explained by the interaction term over the variance explained by the effects of crew motivation and moderator alone. Visibility of outcome has the highest value of ΔR^2 compared to other moderators. The interaction between visibility of outcome

Table 9. Moderators of the relationship between crew motivation and performance.

Situational/ contextual factor category	Factor sub-category	Moderator	Standardized regression coefficients for interaction term	Significance for interaction term	Correlation to crew performance	R^2 change
			β	p-value	r	ΔR^2
Task-related	▪ Task characteristics	Task type	-0.41	0.019	0.15[a]	14%
		Task repetition	-0.49	0.004	0.43[b]	19%
	▪ Task design	Visibility of outcome	-0.62	0.000	0.32[b]	34%
Labor-related	▪ Crew properties	Crew size	0.49	0.012	-0.10[a]	12%
Foreman-related	▪ Foreman characteristics	Foreman knowledge	-0.36	0.002	0.29[b]	9%
	▪ Foreman functional skills	Performance monitoring	-0.39	0.046	0.42[b]	10%
		Communication	-0.43	0.024	0.64[a]	12%
	▪ Foreman behavioral skills	Goal setting	-0.24	0.003	0.33[b]	3%
		Working relationship	-0.64	0.015	0.37[b]	15%
		Building trust	-0.88	0.040	0.48[b]	10%
Management-related	▪ Project and construction management practices	Project time management	-0.56	0.000	0.55[b]	23%
		Project cost management	-0.57	0.000	0.55[b]	23%
Work-setting conditions	▪ Site general facilities	Location of facilities	-0.45	0.000	0.14[b]	28%
	▪ Working area conditions	Congestion	0.42	0.000	-0.84[b]	11%
Total		14				

[a] Correlation is significant at $p<0.05$.

[b] Correlation is significant at $p<0.01$.

and crew motivation explains an additional 34% of the variance in crew performance over the variance explained by the effects of crew motivation and visibility of outcome alone.

The fourth observation from the results in Table 9 is related to the correlations of each moderator to crew performance. Among the identified moderators, task repetition (r=0.43, p<0.01), visibility of outcome (r=0.32, p<0.01), performance monitoring (r=0.42, p<0.01), goal setting (r=0.33, p<0.01), working relationship (r=0.37, p<0.01), and building trust (r=0.48, p<0.01) have a moderate positive relationship with crew performance. Communication (r=0.64, p<0.05), project time management (r=0.55, p<0.01), and project cost management (r=0.55, p<0.01) have a strong positive relationship with crew performance. Congestion (r=-0.84, p<0.01) has a strong negative relationship with crew performance. The two highest absolute correlations are related to congestion (r=-0.84) and communication (r=0.64). Neither of them have the highest amount of either β or ΔR^2, indicating that the situational/contextual factors with the highest absolute correlation may not necessarily have the highest moderating effect.

Discussion

There are some situational/contextual factors, such as visibility, that have a moderate relationship to crew performance but have a strong moderating effect on the relationship between crew motivation and performance. Therefore, to achieve higher levels of crew performance, it is important to improve the moderators of the relationship between crew motivation and performance, such as visibility of outcome. This suggests that moderation is an important issue to be taken into consideration when the goal is to improve crew performance.

The situational/contextual factors related to the foreman-related category have the highest number of moderators, especially those related to foreman behavioral skills, compared to other situational/contextual factor categories. Out of 14 identified moderators, six are in the foreman-related category, which suggests the importance of foreman-related factors to the relationship between crew motivation and performance. Among the situational/contextual factor sub-categories, foreman behavioral skills has the highest number of moderators, suggesting the importance of foreman behavioral skills on the relationship between crew motivation and performance. Past research in construction focused mainly on foreman functional skills as critical factors affecting crew motivation and overlooked foreman behavioral skills (Siriwardana and Ruwanpura 2012). The findings of this paper reveal a need for additional research focused on improving foreman behavioral skills.

The moderators of the relationship between crew motivation and performance are from five types of situational/contextual categories: task-related, labor-related, foreman-related, management-related, and work-setting conditions. Three categories of situational/contextual factors did not include any moderators of the relationship between crew motivation and performance: project characteristics, resources, and safety, indicating that the factors in these categories have a direct effect on crew performance without any moderating effects.

Conclusions and Future Research

In this paper, motivational factors and their associated measures, situational/contextual factors, and crew performance metrics are identified and analyzed. Factor analysis is performed to check the validity and reliability of the identified motivational measures for each motivational factor. The results of factor analysis show both the validity and reliability of motivational measures. Correlation analysis was performed to investigate the relationship between crew motivational factors and crew performance metrics. The results suggest that all motivational factors have a weak positive relationship with task performance, a moderate to strong positive relationship with contextual performance, and a moderate to strong negative relationship with counterproductive behavior. Based on these results, the researchers suggest that promoting positive interactions among crew members, such as more interactive site orientations, safety meetings, or daily meetings, will improve crew performance. Among the motivational factors, commitment/engagement was shown to have the strongest relationship to crew performance, followed by cohesion, then efficacy, and finally identification.

Hierarchical regression analysis was performed to identify the key moderators of the relationship between crew motivation and performance. Among the 129 investigated situational/contextual factors, 14 were shown to have a moderating effect: task type, task repetition, visibility of outcome, crew size, foreman knowledge, performance monitoring, communication, goal setting, working relationship, building trust, project time management, project cost management, location of facilities, and congestion. The situational/contextual factor sub-category of foreman behavioral skills has the highest number of moderators, suggesting the importance of foreman behavioral skills on the relationship between crew motivation and performance.

This paper makes three major contributions: first, it develops a comprehensive set of construction crew performance metrics that relate not only to task performance, but also to contextual performance and counterproductive behavior; second, it reveals how motivational factors affect crew performance; and third, it provides a comprehensive list of the key moderators of the relationship between construction crew motivation and performance. The key moderators identified in this paper as well as the motivational factors will be used to develop models of the relationship between crew motivation and performance in construction. Many of the identified moderators, such as those related to foreman behavioral skills, are subjective variables. Additionally, each project includes different agents, such as crew members and foremen, who not only have different levels of motivation but also interact with each other. Models that are able to incorporate both agent interactions and individual differences in levels of motivation among project agents will help to better assess the impact of crew motivation on performance. Therefore, future research will investigate the development of fuzzy agent-based methods to model the subjective variables and relationships between motivational factors, situational/contextual factors, and crew performance metrics, as well as the interactions among project agents.

Data Availability Statement

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

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Appendix A

Table A.1. Data collection form for the identified moderators of the relationship between crew motivation and performance.

Situational/contextual factors	Scale of measure	Sub-factors	Range of values
Task type	Categorical		1. Civil 2. Mechanical 3. Electrical 4. Instrumentation
Task repetition	Percentage (% of identical tasks in work package over total tasks in work package)		[0%, 100%]
Visibility of outcome	Five-point rating scale		(1) Very low to (5) Very high
Crew size	Integer		$\mathbb{Z}^+$
Foreman knowledge	Five-point rating scale		(1) Very poor to (5) Very good
Performance monitoring	Five-point rating scale		(1) Very poor to (5) Very good
Communication	Five-point rating scale		(1) Very poor to (5) Very good
Goal-setting	Five-point rating scale	• Goal clarity • Goal specificity • Goal difficulty	(1) Very poor to (5) Very good
Working relationship	Five-point rating scale		(1) Extremely ineffective to (5) Extremely effective
Building trust	Five-point rating scale		(1) Very low to (5) Very high
Project time management	Five-point rating scale	• Work breakdown structure (WBS) • Project schedule • Resource requirements	(1) Very poor to (5) Very good
Project cost management	Five-point rating scale	• Project cost estimates • Project budget • Project cash flow	(1) Very poor to (5) Very good
Location of facilities	Real number (average distance, m)		$\mathbb{R}^+$
Congestion	Real Number (number of people per 100 square meter in working area)		$\mathbb{R}^+$