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A FRAMEWORK FOR MEASURING THE IMPACT OF PROJECT MANAGEMENT PRACTICES ON CONSTRUCTION LABOUR PRODUCTIVITY

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Abstract: The evaluation of organizational competencies, such as project management practices, has received significant attention in the construction domain due to its impact on organizational performance. Organizational competencies are difficult to define and measure due to the multidimensional and subjective nature of their associated factors. Previous research has attempted to identify and categorize competencies on the individual and organizational levels to define organizational effectiveness, competitiveness, and profitability. No study has been done to measure the impact of management practices, as part of organizational competencies, on construction labour productivity. This paper presents a framework to identify and measure project management practices that impact labour productivity on construction projects. The proposed framework accounts for both quantitative and qualitative factors related to management practices in construction; it also provides a method of assessing the impact of these practices on construction labour productivity. The implementation of this framework as part of an overall model for predicting construction labour productivity is presented. The paper introduces a method for ranking and identifying the most significant management practices affecting construction labour productivity. Lastly, the paper discusses future work on the integration of the proposed methodology in a comprehensive model that uses fuzzy set theory and artificial intelligence techniques for the assessment of overall organizational competencies and their impact on organizational performance.

1. INTRODUCTION

The construction industry has suffered from the consequences of productivity loss. The main focus of project managers in construction is to ensure the owner's built product is successfully delivered within the constraints of cost, schedule, quality, and safety requirements. However, the missing link between management practices and their impact on different trades executing the physical work has led to a steep loss of productivity over the past decades (Jarkas and Bitar 2012). Several management practices such as communications, resource management, procurement, and time management have been shown to impact labour productivity (Ling et al. 2008). Therefore, project management practices have a significant role in enhancing different performance aspects, so as to increase construction labour productivity.

Prior to investigating their impact on productivity, project management practices need to be identified as a constituent of organizational competencies. Organizational competencies are a key driver of enhancing effectiveness within different occupations, and, accordingly, performance within different sectors (Sparrow 1995). For organizations with limited resources, the ability to identify organizational competencies is an effective starting point from which to begin enhancing overall organizational performance. Sparrow (1995) stated that full utilization of an organization’s resources will assist in achieving high effectiveness rates and enhanced overall performance. Undertaking an organizational competency analysis allows

organizations to gain a competitive advantage, in that this process identifies capabilities and practices that enhance the effectiveness of different processes. The outputs of a competency analysis are expressed in terms of performance indicators to assess organizational performance (Markus et al. 2005). Policies and procedures pertaining to management practices are produced at the organizational level; however, the effect of these procedures affects performance throughout different levels of an organization. One of the areas highly affected by management practices is construction labour productivity. Construction labour productivity is one of the key performance indicators that affects cost, time, and quality on construction sites (PMI 2008).

This paper identifies the relationship between management practices and their impact on construction labour productivity. It proposes a framework and methodology to measure the effect of management practices on construction labour productivity. Following a literature review, a questionnaire that includes different management practices and sub-practices is administered to identify significant management practices affecting construction labour productivity, and to allow for subsequent quantification of the impact of these practices on productivity. The details regarding the framework and methodology for analyzing the resulting data are then discussed. Actual construction labour productivity data and factors related to management practices are collected and documented during this research.

2. BACKGROUND AND LITERATURE REVIEW

Project managers require both significant experience and specialized skills in order to be successful. Identification of project managers' skills has been introduced and discussed in previous research to confirm the essentiality of certain management practices to performing assigned tasks (Edum-Fotwe and McCaffer 2000). Jakar and Bitar (2012) collected data from different construction projects and identified management-related factors affecting construction labour productivity. In that study, a relative importance index was used to prioritize management-related factors affecting construction labour productivity; these factors included deficiencies in documentation, a lack of procurement provisions, and inadequate leadership by project managers. The results of the analysis returned a relative importance index of 54.9% for management practices as a cause of construction labour productivity loss (Jarkas and Bitar 2012).

Many studies on labour productivity analysis and modeling have been conducted, but few of these studies aimed to identify and quantify the impact of management practices on construction labour productivity (Jarkas and Bitar 2012). Additionally, no previous research considered quantitative and qualitative factors related to management practices and their impact on construction labour productivity. Past literature aimed to identify the influence of factors having direct impact on construction labour productivity at the activity level (Song and AbouRizk 2008), but did not examine organizational level factors such as management practices. Data discussed by Song and AbouRizk (2008) stated the importance of "a large amount of comprehensive and accurate historical data", meaning that "years of productivity data must be tracked and stored". Little existing research has aimed to comprehensively investigate the impact of high-level factors such as project management practices on construction labour productivity.

This paper attempts to identify both quantitative and qualitative aspects of high-level organizational factors, specifically project management practices. It then aims to correlate project management practices to construction labour productivity. Factors such as project control, risk management, time management, and other project management areas, as stated in the Project Management Body of Knowledge (PMBOK), affect the entire project life cycle—of which productivity is one major factor (PMI 2008). Therefore, it is essential to determine which project management practices affect construction labour productivity, so that these practices can be enhanced in order to improve productivity. Figure 1 outlines the framework for the study described in this paper.

Construction labour productivity depends on both existing organizational policies and procedures, and the implementation or practice of these rules and guidelines. Even if policies and procedures remain static, their application can differ from project to project due to a variety of factors, and productivity can be affected in a variety of ways as a result. The framework proposed in this research maps the relationship between management practices and the impact of these practices on construction labour productivity.

3. RESEARCH FRAMEWORK AND METHODOLOGY

In order to quantify the impact of management practices and sub-practices on construction labour productivity, a framework is proposed. The framework, outlined in Figure 1, highlights the different stages of developing a standardized management practices list with adequate measurement scales for each of the management practices. A more detailed description of the different stages involved in developing a management practices list and a measurement scale is presented in the following section.

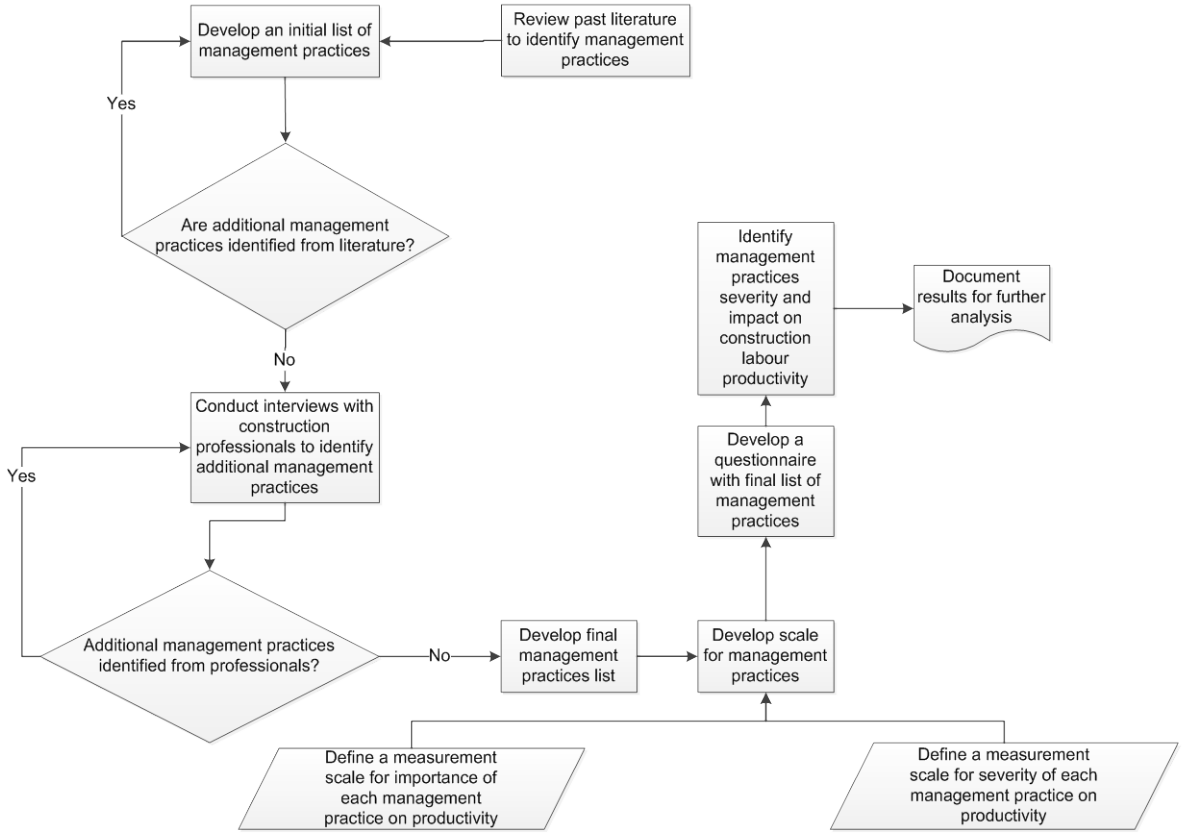

Figure 1: Framework for developing management practices affecting productivity

3.1 Identification of Management Practices Affecting Construction Labour Productivity

The identification of management practices and sub-practices, and their impact on construction labour productivity, is initiated by the determination of which practices are to be included. The initial list is derived from the nine knowledge areas described in the PMBOK. The list is then complemented by a comprehensive review of past literature to include management practices identified in previous research (Awad and Fayek 2011; CII 2011; Elbarkouky and Fayek 2010a; Elbarkouky and Fayek 2010b; Jarkas and Bitar 2012; Marsh and Fayek 2009; Menches et al. 2005; PMI 2008).

Once the development of a more comprehensive list of management practices and associated sub-practices is completed, a series of group discussions with construction professionals is initiated. The final list of management practices and associated sub-practices is introduced to an appropriate sample size of construction practitioners who occupy various management level positions, ranging from middle to senior management levels on the organizational level and the field level, and who represent a diverse range of experience. This step is intended to verify the efficacy of the developed list of management practices and associated sub-practices. Construction professionals' suggestions are incorporated into the developed list

prior to developing the questionnaire to determine the effect of management practices and their associated sub-practices on construction labour productivity.

The final list of management practices will result from both the extensive past research investigation and the interviews with construction professionals. Thirteen main management practices that have already been identified are: 1) integration management, 2) scope management, 3) time management, 4) cost management, 5) quality management, 6) human resource management, 7) procurement management, 8) safety management, 9) risk management, 10) change management, 11) communications management, 12) business development management and 13) project delivery system management.

Once a comprehensive list of management practices and sub-practices has been compiled, two scales will be used to measure the identified management practices and associated sub-practices. A five-point severity scale has been developed to quantify the extent to which a given management practice exists within a construction organization. A seven-point importance scale identifies the importance of each management practice in affecting construction labour productivity, and allows for prioritizing and ranking of the factors based on a relative importance index that will be discussed later in this paper. For example, if two management practices are determined to have the same relative importance index based on their importance scales, then the severity scale will determine the extent of the impact of each of the two practices on construction labour productivity. Furthermore, the severity scale will be used in the future for the development of an empirical model to determine the effect of each management practice on construction labour productivity.

For the severity scale, a systematic methodology is proposed to divide each management practice or sub-practice according to three main criteria of equally distributed weights. These criteria enable assessment of the extent to which each of the practices and sub-practices affects construction labour productivity. The practices will be categorized to develop the severity measurement scale using the following criteria: availability of guidelines for the practice, existence of monitoring and updating processes of the available guidelines, and existence of performance measurement criteria for the practice.

For example, time management will be assessed against the following three main criteria to calculate its severity index:

1. Availability of guidelines at the organizational level that are used for time schedule development;
2. Existence of proper monitoring and updating processes for the developed time management guidelines; and
3. Availability of a criteria/indicator to measure the impact of time management practice on performance.

Once the final list of management practices and sub-practices has been developed, the scale displayed in Table 1 will be used to determine the severity of each practice and sub-practice on construction labour productivity. The severity scale minimizes subjective interpretation of respondents to the questionnaire, and provides a systematic approach for determining a measurement of severity for each of the management practices and sub-practices regarding their effects on construction labour productivity. The proposed severity scale aims to cover all applicable scenarios for the different management practices in the final list. The index resulting from the severity scale will eventually be used in the development of an analytical model to quantify the impact of management practices on construction labour productivity.

Table 1: Severity scale for management practices

Severity Scale Value	Severity Scale Description
1	The practice does not exist within the organization
2	The practice exists but none of the predetermined criteria is satisfied
3	One of the predetermined criteria is satisfied
4	Two of the predetermined criteria are satisfied
5	All predetermined criteria are satisfied

In contrast to the severity scale, the seven-point importance scale serves two purposes: to determine the importance of a management practice or sub-practice in affecting construction labour productivity, and to allow for proper ranking of these practices in relation to each other. In the importance scale, a value of 1 indicates that a practice or sub-practice is extremely unimportant, a value of 2 that a practice or sub-practice is unimportant, a value of 3 that a practice or sub-practice is slightly unimportant, a value of 4 that a practice or sub-practice is neither unimportant nor important, a value of 5 that a practice or sub-practice is slightly important, a value of 6 that a practice or sub-practice is important, and a value of 7 that a practice or sub-practice is extremely important.

3.2 Determination of Most Significant Management Practices Affecting Construction Labour Productivity

The list of management practices and associated sub-practices will be compiled into a questionnaire to be completed by construction professionals to determine the importance and severity of different management practices and sub-practices in regards to construction labour productivity. A sample questionnaire is displayed in Table 2. The questionnaire will include the 13 management practices and their associated sub-practices. The severity index is intended for future use in more detailed calculations during the development of a model to measure construction labour productivity, while the importance scale is intended for the prioritization and ranking of the management practices and sub-practices, which is discussed in this paper.

Table 2: Sample questionnaire with measurement scales

Project Management Practices and Sub-Practices	Severity Scale (1-5)	Importance Scale (1-7)
Risk Management	1 2 3 4 5	1 2 3 4 5 6 7
Risk identification process	1 2 3 4 5	1 2 3 4 5 6 7
Risk analysis and monitoring process	1 2 3 4 5	1 2 3 4 5 6 7
Safety Management	1 2 3 4 5	1 2 3 4 5 6 7
Use of daily job hazard assessment forms	1 2 3 4 5	1 2 3 4 5 6 7
Use of site safety meetings	1 2 3 4 5	1 2 3 4 5 6 7
Frequency of drug testing	1 2 3 4 5	1 2 3 4 5 6 7
Number of safety inspections	1 2 3 4 5	1 2 3 4 5 6 7
Cost Management	1 2 3 4 5	1 2 3 4 5 6 7
Frequency of cost reporting	1 2 3 4 5	1 2 3 4 5 6 7
Use of Earned Value Analysis techniques	1 2 3 4 5	1 2 3 4 5 6 7

The developed questionnaire will be distributed among different organizations and sectors to gather a wide range of responses regarding the severity and importance of the different management practices and sub-practices in regards to construction labour productivity. A relative importance index will be determined—using the importance scale—for each of the practices and sub-practices using Equation 1.

Relative importance is often used in two main areas to indicate significance. In some cases relative importance indicates statistical significance, while in other cases – as used in this paper – it indicates practical significance (Tonidandel and LeBreton 2011). The relative importance index supplements the overall output of analyzing management practices by providing a numerical value that represents the overall rank of a given management practice within the entire list of management practices (Chan and Kumaraswamy 1997; Aibinu and Jagboro 2002).

Management practices will subsequently be ranked based on their relative importance index, calculated as shown in Equation 1. Here, n_1, n_2, n_3, n_4, n_5, n_6, and n_7 are the number of respondents who selected: 1 for extremely unimportant, 2 unimportant, 3 slightly unimportant, 4 neither unimportant nor important, 5 slightly important, 6 important, and 7 for extremely important practices.

[1] Relative Importance Index (%) = $\frac{n_1+2n_2+3n_3+4n_4+5n_5+6n_6+7n_7}{7(n_1+n_2+n_3+n_4+n_5+n_6+n_7)} X\ 100$

3.2.1 Illustrative Example for Determining Most Significant Management Practices

Assume a sample of 20 questionnaires regarding management practices was collected from senior construction professionals. Gathered data were analyzed, and a relative importance index was identified based on the participants' feedback regarding their expectation of the impact of management practices on construction labour productivity. It is important to note that sub-practices identified in the questionnaire will be used in a later stage to quantify the impact of management practices numerically.

The relative importance index of each practice was calculated using Equation 1 above. For example, the relative importance index for the human resource management practice was calculated as follows:

[2] Human resource management relative importance index (%) = $\frac{1+2x0+3x\ 2+4x1+5x1+6x\ 7+7x8}{7(1+0+2+1+1+7+8)}$ x 100 = 81.4

Based on the relative importance index for each of the 13 management practices, the management practices can be ranked as shown in the hypothetical example in Table 3.

Table 3: Ranked management practices based on their relative importance index

Practice	Practice Relative Importance Index (%)	Rank
Human Resource Management	81.4	1
Safety Management	81.3	2
Cost Management	80.1	3
Scope Management	77.7	4
Time Management	60.5	5
Change Management	60.2	6
Project Delivery System Management	55.4	7
Quality Management	46.4	8
Communications Management	44.3	9
Risk Management	43.6	10
Business Development	43.4	11
Integration Management	43.3	12
Procurement Management	35.7	13

3.3 Measuring Impact of Project Management Practices on Construction Labour Productivity

The field data collection phase will quantify the sub-practices associated with the different project management practices affecting construction labour productivity. Sub-practices measured will account for both the quantitative and qualitative aspects of project management practices. This step will take place on construction sites of organizations who participated in completing the survey. Table 4 lists a sample of sub-practices for which data will be collected for future development of a model that measures the effect of different management practices on construction labour productivity. The sub-practice provides a description of the information to be collected on site. The scale of measurement indicates the data collection format. The data collection cycle indicates how often the sub-practice will be measured.

Table 4: Sample sub-practices

Management Practice	Sub-Practice	Scale of Measurement	Data Collection Cycle	Example Collected Value
Risk Management	Frequency of risk register update	Number of risk register updates per month	Monthly basis	2
	Monitoring risks process	Predetermined scale (1. No monitoring; 2. Infrequent monitoring; 3. Frequent monitoring)	At the beginning of a project or start of data collection cycle	3
Safety Management	Use of daily job hazard assessment forms	Categorical (Yes/No)	At the beginning of a project or start of data collection cycle	Yes
	Use of site safety meetings	Number of meetings per month	Monthly basis	4
	Drug testing	Categorical (Yes/No)	At the beginning of a project or start of data collection cycle	Yes
	Safety Inspections	Number of inspections per month	Monthly basis	12
Cost Management	Frequency of cost reporting	Number of reports per month	Monthly basis	1
	Budget status	Categorical (Under budget- On budget- Above budget-)	Monthly basis	Above budget

4. CONCLUSIONS AND FUTURE RESEARCH

Understanding and quantifying the impact of management practices on different performance measures, such as construction labour productivity, is a primary step in enhancing overall construction performance. This study proposes a framework for identifying and measuring different management practices and sub-practices and their impact on construction labour productivity. Based on past literature and interviews with construction professionals, the research develops a comprehensive, standardized list of management practices and, finally, an approach for identifying management practices affecting construction labour productivity. Additionally, this paper proposes a methodology by which the severity and impact of management practices on construction labour productivity can be quantified. The severity scale will be used for developing a future model to quantify the magnitude of different management practices on construction labour productivity. The importance scale is used to prioritize and rank management practices by calculating the relative importance index of each of the management practices. To complement the determination and ranking of project management practices and sub-practices, field data collection for management sub-practices will be conducted; this step quantifies the sub-practices and allows for the future development of a model that will be capable of analytically measuring the impact of each of the practices and sub-practices on construction labour productivity. Linking the construction labour productivity impacts of management sub-practices to their respective management practices is expected to improve the latter and, accordingly, to improve construction labour productivity.

That data collected through the proposed methodology will be used to develop a model to analytically measure the impact of project management practices on construction labour productivity. Future work

based on this research will use empirical methods, such as multiple regression analysis, to determine the most significant management practices that have an impact on construction labour productivity. In the long term, this research will develop an overall productivity prediction and optimization model, based on a combination of qualitative and quantitative factors, including management practices and sub-practices. Fuzzy logic, combined with other artificial intelligence techniques, such as artificial neural networks and genetic algorithms, will be used in modeling qualitative and quantitative factors affecting labour productivity. An aggregation method will be developed to combine qualitative and quantitative data for processing within the model.

The results of the model are expected to provide a quantification of construction labour productivity loss/gain resulting from various levels of implementation of management practices. The proposed model will enable construction practitioners to identify and flag management practices that require attention and the extent of the impact of these practices on construction labour productivity. Furthermore, the proposed model will have the capacity to map macro level factors, such as management practices developed and implemented by organizations, onto micro level factors affecting construction workers on site. This mapping capability of the proposed model will facilitate the use of different approaches to enhance both construction workers' productivity as well as implemented management practices. For example, if the change management practice applied by an organization disrupts ongoing construction activities, then the proposed model will provide the capability of highlighting this practice and providing quantification of the extent of its impact on construction labour productivity. Furthermore, improvement to this practice can be mapped and expressed in terms of construction labour productivity improvement.

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