A More Effective Labour Management Model for Construction Projects to Increase Productivity and Enhance Profitability

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***Abstract:** Construction industry is labour intensive compared to other sectors with a range of 25-30 %. According to Wibowo (2002), the industry comprises of three major inputs namely labour, equipment and materials. Labour is therefore unpredictable in nature compared to other inputs (materials and equipment) which are affected and determined by the current market rates. Therefore, proper labour management is required all through the construction process; this can be achieved by introduction of effective management models for use in the construction industry. The research sought to develop an affective labour management model which can be used to increase productivity. The research used questionnaires and interviews to seek information from the practicing construction personnel who expressed their views and gave their opinions concerning labour management. The study found out that most practitioners are aware of the labour management models and their contribution in increasing productivity and some admitted that they have not used the models due to their complexity. The study used inferential statistics to generate correlation, which aimed to examine and describe the association and relationship between individual factors and their relationship to labour productivity. All factors affecting productivity were grouped in to five thematic coefficients which were used to create a model. The five coefficients are Labour planning (plan), Training of workforce (train), Motivation of labour (motivate), Mechanization of labour (mech) and availability of raw materials (raw). The model developed is:*

Productivity = βplan + βtrain + βmotivate + βmech + βraw + βplan: βmech + $\beta_0 + \varepsilon_i$

Logistic odds were assigned to each individual coefficient in order to give the model a simpler meaning; the odds generated were as shown below.

Productivity = 3.29plan + 1.31train + 0.85motivate + 2.7mech + 0.93raw + (3.29plan: 2.7mech) + constant (intercept)

***Index Terms:** Labour, Labour Management Model, Labour Productivity, Production Efficiency.*

I. INTRODUCTION

Construction industry contributes significantly in terms of scale and share in the development process for both developed and developing countries (Wibowo, 2002). The construction products provide the necessary public infrastructure and private physical structures for many productive activities such as services, commerce, utilities and other industries. The industry is not only important for its finished product, but it also employs a large number of people (directly and indirectly) and therefore has an effect on the economy of a country during the actual construction process (Wibowo, 2002). Construction industry in Kenya is rapidly growing and this is evident with the government's target on the vision 2030which aims to improve the countries infrastructural development, ranging from roads, ports and establishment of new cities.

According to economic survey (2015), the construction and building industry in Kenya contributes to 4.8 percent of the Gross Domestic Product (GDP), and this illustrates economic significance of the industry in the countries growth. The cost of building projects is determined by several factors such as the cost of materials, construction plant and equipment, labour, overheads and profits involved in its erection (Seeley, 1995). According to Abou Rizk et al (2001), labour contributes to approximately 30 percent of the total project cost. Therefore, in the above-mentioned factors, labour is considered critical due to its larger impact in terms of percentage as a cost determinant in the overall project cost.
Labour productivity is considered one of the best indicators of production efficiency. Higher productivity usually yields superior profitability (Rojas and Aramvareekul, 2003). It is therefore evident that if the labour production per activity is poorly managed it will lead to extended completion time and costly project leading to reduced profits or even escalated project cost, which is referred to as time and cost overruns respectively. . Effective labour management is therefore key in ensuring that tasks are completed on time, within the budget to maximize profit margins as well as minimizing disputes that arise as a result of delayed project delivery, (Rojas and Aramvareekul, 2003). This study therefore sought to fill the existing gap by developing an effective labour management model.

II. OBJECTIVES OF THE STUDY

- To develop a more effective labour management model for construction projects to increase productivity and enhance profitability in Kenyan construction industry.
- To study the relationship between labour, material, management, and equipment related factors to productivity.

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- To investigate the relationship between productivity, cost and time overruns in Kenya's construction industry.
- To study the relationship between labour productivity and contractors profit margins in Kenya's construction industry.

III. RESEARCH METHODOLOGY

This research used a mixed strategy where both qualitative and quantitative approaches were used interchangeably. Considering the objectives in the study a survey design was considered suitable where data was collected through self-administered questionnaires and structured interviews. The target population was contractors registered as NCA 1 to NCA 5 within Nairobi County. Respondents were chosen randomly with a target of 97 contractors which was arrived on the formulae shown below.

$$n=n^! / \{1+ (n^! /N)\} \quad (1)$$

Where:
N= Total number of population
n= Sample size from finite population
n$^!$= sample size from infinite population $=S^2/V^2$, where S^2 is the variance of the population elements and V^2 is the standard error of sampling population. (Usually **S**=0.5 and **V**=0.05).

The total number of the registered contractors (N) was obtained from the National Construction Authority website (2016) (http://www.nca.go.ke/index.php/k2/contractors-center/search)

n$=n^! / \{1+ (n^! /N)\}$

N = 2550

n$^! = S^2/V^2 = 0.5^2/0.05^2 = 100$

$n= 100/ \{1+(100/2550)\} = 96.246$

This translates to 97 respondents.
A total number of 150 questionnaires were issued both manually and electronically, however a total number of 85 respondents returned the questionnaires which was equivalent to a response rate of 87.6% compared to the targeted number of respondents.

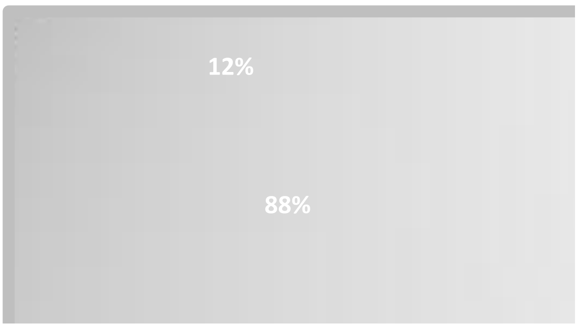

Fig 1. Response Rate. Source: Author, 2017

Both Qualitative and Quantitative data were used. Quantitative data was critical and was achieved by the use of a five points likert scale. Qualitative data could not be left out as the researcher felt it was critical to seek more information from the respondents and open ended questions were used in specific questions which needed more clarification or explanation. A pilot study was conducted to ensure that the questionnaire was not ambiqous and that it was clear enough to seek required information from the respondents. After the pilot study, several changes were made and the final questionnaire was prepared which was used to collect data.

IV. RESEARCH FINDINGS

A. Demographic Findings of the Respondents

The study sought to establish the profile of the respondents in terms of the highest level of education, professional qualification and experience in the construction industry. The study also sought information on respondents' employing construction company in terms of NCA registration. The characteristics of study subjects were described using frequencies and percentages as shown in table 1.

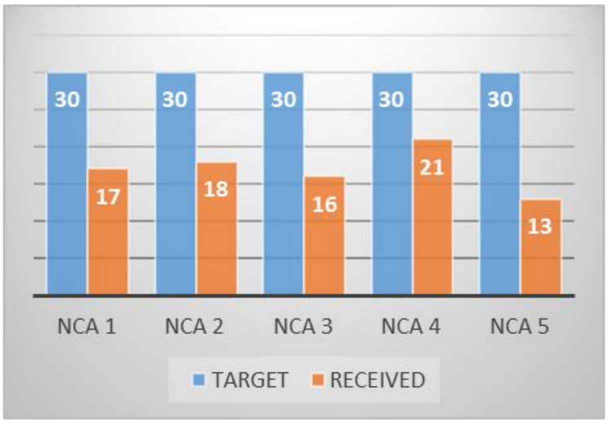

Fig 2. Targeted and Received Responses. Source: Author, 2017

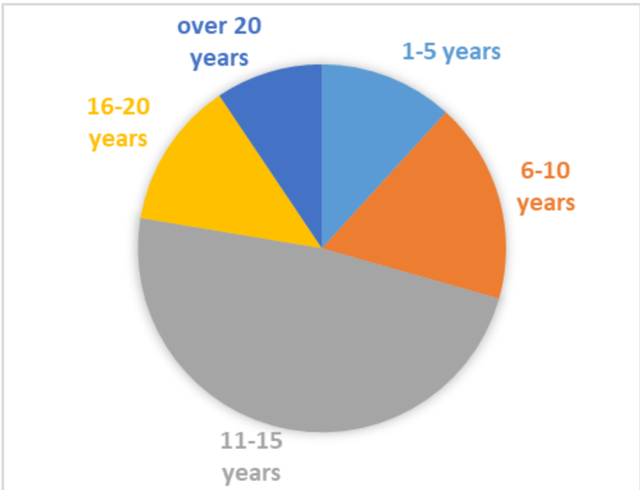

Fig 3. Summary of the Respondents' Years of Experience
Source: Author, 2017

The table below shows a summary of the findings of personal information of the respondents examined.

Table 1. Findings of Personal Information of the Respondents Examined

Variable	Values	Frequency	Percentage (%)	Cumulative Frequency
Registration Category	NCA1	17	20.00	20.00
	NCA2	18	21.18	41.18
	NCA3	16	18.82	60.00
	NCA4	21	24.71	84.71
	NCA5	13	15.29	100
Educational background	Architecture	8	9.41	27.06
	Civil & Structural Engineering	21	24.71	51.77
	Building construction	18	21.18	72.95
	Quantity Surveying	14	16.47	89.42
	Mechanical Engineering	6	7.06	96.48
	Electrical/Services engineering	3	3.52	100
Participants role	Project contractor	62	72.94	72.94
	Project Architect	3	3.53	76.47
	Clerk of works	4	4.71	81.18
	Foreman/ site agent	10	11.76	92.94
	Quantity Surveyor	2	2.35	95.29
	Mechanical engineer	2	2.35	97.64
	Electrical engineer	1	1.18	98.82
	Others	1	1.18	100
Nature of the project	Residential	57	67.06	67.06
	Commercial	24	28.24	95.30
	Civil	4	4.70	100
Project financier	Private Developer	58	68.24	68.24
	County Government	13	15.29	83.53
	Central Government	9	10.59	94.12
	Non-Government organizations	3	3.53	97.65
	Others	2	2.35	100
Period of operation	1-5 years	10	11.76	11.76
	6-10 years	15	17.65	29.41
	11-15 years	41	48.24	77.65
	16-20 years	11	12.94	90.59
	Over 20 years	8	9.41	100
Firms category	National (local) firms	68	80.00	80.00
	African firms	15	17.65	97.65
	International (foreign firms)	2	2.35	100

Source: Field survey 2017

The information above on table 1, which also corresponds with figure 2 shows that(17 no.) 20% of the respondents were working with contractors, registered as NCA 1, 21.18 % (18 no.) under NCA 2, 18.82 % (16 no.) NCA 3, 24.71(21no.) NCA 4 and 15.29(13 no.) under NCA 5.

The educational background of the respondents was also considered with the highest number being civil and structural engineers at 24.71 %, followed by building construction at 21.18%, quantity surveyors 16.47 %, Architects 9.41 %, mechanical engineers 7.06 % and finally services engineers with 3.53 %.

Participants' role was analyzed and most respondents were contractors with 72.94 % as shown in table 1 above.

Most of the respondents were working on residential houses at 57%, followed by commercial houses at 24 % with only 4 % working on civil works.

Respondents experience was also analyzed and most respondents had experience of between 11-15 years at 48.24 %, 1-5 years had 11.76%, 6-10 years 17.65 %, 16-20 years 12.94 % and above 20 years had 9.41 %. The mean experience was 12.19 years as shown in table 2 below.

Table 2. Mean Experience of the Respondents

Experience (years)	Mid value (X)	Frequency (F)	FX
1-5	2.5	10	25
6-10	8	15	120
11-15	13	41	533
16-20	18	11	198
Over 20	20	8	160
TOTAL		***85***	***1036***
Mean Years of Experience = ΣFX/ΣF=12.19			***(1036/85)***

Source: Field survey 2017

This indicates that information was gathered from respondents with many years of experience and therefore increases the level of confidence on the information given

B. Testing the Questionnaires Reliability

Cronbach's alpha was used to test the questionnaires reliability. It assesses the reliability of a summative rating (Likert) scale composed of the variables (called items) specified.

Cronbach alpha decision rules

alpha > 0.9	Excellent
0.8 = alpha < 0.9	Good
0.7 = alpha < 0.8	Acceptable
0.6 = alpha < 0.7	Questionable
0.5 = alpha < 0.6	Poor
alpha < 0.5	Unacceptable

The resulting coefficient of reliability ranges from 0 to 1 in providing this overall assessment of a measure's reliability. If all of the scale items are entirely independent from one another (i.e., are not correlated or share no covariance), then alpha = 0; and, if all of the items have high covariance's, then alpha will approach 1 as the number of items in the scale approaches infinity.

The questionnaire had a Cronbach alpha of 0.75, which is acceptable and suggested that it measured the same underlying concept.

C. Development of a Model

Given the dependent variable (outcome) for the study was binary, logistic regression was carried out and the logistic regression equation followed the equation of a straight line as shown below.

$$y = \beta_1 x_1 + \beta_2 x_2 + \ldots\ldots \beta_n x_n + \beta_0 + \underline{\varepsilon}_I \qquad (2)$$

Whereby;

y = Outcome variable (labour productivity)
β = Regression coefficient estimates
$x_{1\ldots n}$ = Labour productivity factors
$\underline{\varepsilon}_i$ = Error term

The study developed two models where model 1 failed but model 2 proved to be reliable and passed all the tests carried out. Codes ranging from 1 to 5 were assigned to each variable and then summed, an average score was computed for each thematic section of the questionnaire. All factors affecting labour productivity were grouped in to five latent variables which were then used to develop the model.

The latent variables created where labour planning, training of workforce, motivation of labour, mechanization of labour and availability of raw materials.

Initial analysis of the logistic regression equation (Model 1) included the labour productivity factors and an interaction term between labour planning and motivation of labour, the equation is shown below.

$$\textbf{Productivity} = \beta plan + \beta train + \beta motivate + \beta mech + \beta raw + \beta plan: \beta motivate + \beta_0 + \underline{\varepsilon}_I \qquad (3)$$

Whereby;

Productivity = Labour productivity
Plan = Labour planning
Train = Training of workforce
Motivate = Motivation of labour
mech = Mechanization of labour
Raw = Availability of raw materials
Plan: motivate = Interaction term between labour planning and motivation of labour.

The above equation has an overall good fit for the data with a Hosmer Lemeshow goodness of fit test of χ^2 at d.f = 3, 50.17, p-value = p<.05 (0.0000) of which implies that at $\alpha = 0.05$ the model fits the data. However, one of the variables (availability of raw materials) in this model is not a significant predictor of labour productivity at $\alpha = 0.05$ with a p-value = p>.05 (0.05203). This therefore indicates that the model has failed.

Another logistic regression equation (Model 2) was developed which was the final equation used for analysis and included an interaction term between labour planning and mechanization of labour.

$$\textbf{Productivity} = \beta plan + \beta train + \beta motivate + \beta mech + \beta raw + \beta plan: \beta mech + \beta_0 + \underline{\varepsilon}_I \qquad (4)$$

The above equation fits the data well at $\alpha = 0.05$ with a Hosmer Lemeshow goodness of fit test of χ^2 at d.f = 3, 26.82, p-value = p<.05. This model therefore passed all the tests and was found to be reliable. Table 3 below shows a summary of both models.

Table 3. Summary of Analysis for the Developed Models

	Model 1				Model 2			
Variables	β		SE	OR	β		SE	OR
Constant	118.0727	**	39.4339	-	-82.8043	*	36.7424	-
Labour planning	-1.1036	*	0.4344	0.33	1.1919	**	0.4368	3.29
Training of workforce	0.3054	***	0.0694	1.36	0.2673	***	0.0706	1.31
Motivation of labour	-2.7401	**	0.9261	0.06	-0.1623	***	0.0315	0.85
Mechanization of labour	-0.3113	***	0.0447	0.73	0.9937	*	0.5017	2.70
Availability of raw materials	-0.0520	.	0.0267	0.95	-0.0590	*	0.0271	0.93
Labour planning: Motivation of labour	0.0291	**	0.0105	1.03	-	-	-	-
Labour planning: Mechanization of labour	-	-	-	-	-0.0147	*	0.0059	0.99
-2LL	46.43				45.89			
χ^2	92.85, df = 6, p<.001.				91.78, df = 6, p<.001.			
Nagelkerke R^2	35.52%				35.17%			
Hosmer Lemeshow test	p = <.001				p = <.001			

Source: Field survey 2017

Notes:
. =p<.01,=p<.05, **=p<.01, ***=p<.001.*
SE - Standard Error
OR - Odds Ratio

D. Regression Output Interpretation

From the final logistic regression equation (Model 2) the following interpretation can be made on the labour productivity factors relationship on the outcome variable labour productivity.
The hypothesis tested is

Null hypothesis:
The labour productivity factors do not contribute significantly to the model or labour productivity factors have no significant relationship with labour productivity. The null hypothesis can be statistically stated as;

$$H_o : \beta_1 = \beta_2 = \ldots\ldots \beta_n = 0 \qquad (5)$$

Alternative hypothesis:
At least one of the labour productivity factors contributes significantly to the model or at least one of the labour productivity factors has a significant relationship with labour productivity. This can be statistically stated as;

$$H_a : \text{At least one } \beta_n \neq 0 \qquad (6)$$

The overall significance of the logistic model given by the Likelihood Ratio Test (LRT) is χ^2 at d.f = 6, 91.78, p-value = p>.001 implies that at α = 0.05 the labour productivity factors contribute significantly to the prediction of labour productivity. We can therefore conclude that there is a statistical significance for all factors under the equation analysis. This can be further confirmed using Wald tests that are used to evaluate the significance of a single coefficient in the model. The Wald tests for each of the coefficients in the model are as shown in table 4 below;

Table 4. Wald Tests for Single Coefficients in the Adopted Model

Coefficients	χ^2	d.f	Wald		95% confidence interval	
Constant	5.1	1	-	*	-	-
Labour planning	7.4	1	3.29	**	1.4477	8.1845
Training of workforce	14.3	1	1.31	***	1.1415	1.5073
Motivation of labour	26.5	1	8.50	***	0.7973	0.9027
Mechanization of labour	3.9	1	2.70	*	1.0420	7.6273
Availability of raw materials	4.8	1	0.94	*	0.8933	0.9942
Labour planning: Mechanization of labour	6.3	1	0.99	*	0.97361	0.9964

Source: Field survey 2017

The logistic regression coefficients give the amount of log odds increase in labour productivity when labour productivity factors are properly managed. They can be converted to odds ratios for easy interpretation whereby they would then suggest the increase in odds of labour productivity given the labour productivity factors are properly managed.

The following is an interpretation of the odds ratio as well as the probabilities of project success for each of the labour productivity factors.

- Labour planning

Odds of high labour productivity increase by a factor of 3.29 times per unit increase in labour planning controlling for all other factors in the model.

- Training of workforce

Odds of high labour productivity is 1.31 times higher per unit increase in proper training of labour controlling for all other factors in the model.

- Motivation of labour

Odds of high labour productivity is 0.85 times lower per unit increase if labourers are not motivated to work controlling for all other factors in the model.

- Mechanization of labour

Odds of high labour productivity is 2.7 times higher per unit increase in mechanization of labour works controlling for all other factors in the model.

- Availability of raw materials

Odds of high labour productivity is 0.93 times lower per unit increase when raw materials are not readily available for use controlling for all other factors in the model.

- Intercept

The intercept (constant) represents the logit of probability of high labour productivity if all the labour productivity factors are absent. Therefore, the coefficient for the intercept represents a decrease in the log odds of high labour productivity by -82.8043 given that all the other labour productivity factors are absent.

V. CONCLUSION

The study looked in to depth specific factors that affect labour productivity and its relation to cost and time overruns. After thorough search of information from the construction participants, it was noted that labour remains to be the most unpredictable component in the project delivery process. Despite most respondents saying that they are aware of several models, which can be applied to monitor or control labour, they accepted that they rarely put them to practice and this has seen contractors' spending more on labour than the initial budgeted cost. The research grouped all those factors into five thematic coefficients which were then studied and a regression analysis carried out. A factor based model was established which went a series of tests and found out to be effective. It is recommended that this model be put into proper use since it emanates from the practical site activities whereby the odds assigned to each activity shows the weight of that particular activity.

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