ADDIS ABABA UNIVERSITY SCHOOL OF GRADUATE STUDIES
ADDIS ABABA INSTITUTE OF TECHNOLOGY (AAIT)
SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING
(CONSTRUCTION TECHNOLOGY AND MANAGEMENT STREAM)

A Factor model to predict the construction labour productivity in building Project: A Case study of Meles Zenawi leadership academy construction project

A Thesis submitted to School of Graduate Studies of Addis Ababa University in partial fulfilment of the requirements of the Degree of Master of Science in Civil Engineering (Construction Technology and Management)

By: Kwizera Arnaud
Advisor: Abraham Assefa (PhD)

March 2019, Addis Ababa

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Abstract

In the construction industry, labor productivity is a key variable in the profitability of a construction project. The most challenging issue for planning a construction project is predicting the construction labor productivity (CLP) because it is affected with many factors that are objective and subjective ranging from internal to external. Based on review of the literatures, several research on CLP have been done in the past; however, a deeper understanding is still needed to control the construction labor productivity because parameters (factors and practices) influencing construction labor productivity are multi-faceted and project dependent. In an attempt to predict CLP in construction projects, this research aims to identify, classify and quantify parameters (factors and practices) influencing the CLP of concrete placement, Rebar and formwork using a case study at the construction of the Meles Zenawi leadership academy situated at Goro by developing a multiple regression model .In this paper, the effective factors that affect the CLP were taken from a large literature review and 20 factors were classified into Management, Labor/human, technological and external termed based on the findings . In total, 222 data points have been collected for a period of two months on both daily and weekly basis. Multiple regression models have been developed for each activity. The slab formwork, column formwork, lift formwork and rebaring presented significant models with a coefficient of determination of 77.6%, 47.0%, 82.6% and 82.7%, respectively. In slab formwork activity, the study results indicated that increased crew size and complexity of the task decrease the CLP. In column formwork, the increase in level of interruption and disruption, crew size, working conditions and temperature will tend to lower the CLP, while the increase in the skills of labor and will increase the CLP. In lift formwork, the model shows that the increase in crew size, shortage of materials will decrease the CLP, whereas the increase in the crew experience and skills labor will increase it. For the rebaring activity the increase in skilled labor and clarity of technical specifications will considerably increase the CLP. In the study, the improvement strategies are also discussed.

Key words: Factors affecting the productivity construction labor productivity (CLP) multiple regressions

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List of Abbreviations

CLP	Construction Labor Productivity
r	Pearson Correlation Factor
R square	Coefficient of Determination
F	F-test
Sig	P-value
CBR	Case Based Reasoning
UAE	United Arab Emirates
PDP	Predicted Daily Productivity
MWUD	Ministry of Work and Urban Development
GDP	Gross Domestic Product
NBE	National Bank of Ethiopia

Chapter 1: Introduction

1.1. Background of the study

Construction industry is a significant contributor in the economic growth of a country. In developed countries, the construction industry incorporates the GDP growth of 7-10%, whereas in under developed countries the percentage is only 3-6 % (Sana and Muqeem 2012). Construction industry is an important element in the economic growth of Ethiopia and it constituting almost 6% of the country's GDP of the country .In light of making the industry profitable, many researchers have been working tirelessly to improve the efficiency of the construction labor productivity which is a key indicator of both the performance of construction industry and the success of a construction project. Labor is one of the most crucial resources used to measure construction productivity constituting large portion of the project cost. Construction labor productivity (CLP) affects the profitability of construction companies. However, CLP are highly variable that are influenced by many factors which makes it a major source of project risk (Tsehayae and Fayek 2014). In Ethiopia, contractors typically use previous projects rates to predict production rates of future projects and do not account different factors and parameters that affect project from place to place. (Muqueem and Khamidi 2011) found that the use of previous projects production rates for estimation of future projects requires a readjustment for each project and takes into account the various site factors and conditions that influence the CLP for construction operations. In this research, a list of multi-level factors and practices were identified through the literatures, ranked and then a factor model to predict CLP will be developed by taking the influencing factors and parameters as the independent variables.

Construction productivity models explain productivity variations by the factors included in the model. The models are useful for construction planning, estimating, and scheduling. In planning, productivity models of controllable factors (such as crew size or scheduled overtime) are needed for maximizing labor productivity to achieve lower labor cost and shorter project duration. In estimating, productivity models are used to predict labor costs; while in scheduling, productivity models are needed to forecast activity durations.

Although productivity modeling is an important part of construction planning, estimating, and scheduling, models developed so far are limited in explaining the variations of productivity and much different from one place to another and are project dependent. Most of models developed in the past used a single factor while neglecting the variations caused by other factors. Additionally, Olabosipo et al (2011) indicated that "influencing factors are rarely constant and may vary from country to country, from project to project, and even on the same project depending on the circumstances, which subsequently affect productivity". In this research, the model will be developed based on a number of the factors and parameters for accuracy in case of the construction project in Addis Ababa.

1.2. Construction productivity variables

The prediction of the value of CLP accurately in construction project is the basis for decision making in planning, bidding, and control of the execution of the project. Extensive work has been done by researchers in terms of identifying factors influencing the productivity of labor on site such as weather, lack of equipment and material, labor skills, incompetent supervision, incompetent drawing, poor communication, change orders, late payments. Also many researchers have studied the relationship of these factors with productivity to evaluate the impact of those factors. Some of the previous studies on construction labor productivity in construction sector include:

Rojas and Aramvareekul (2003) conducted a study to investigate labor productivity drivers and productivity in the US construction sector. The study surveyed different projects (e.g. contractor, consultant, owner etc.) and determined that the worker management skills and manpower matters are the two core enhancement drivers.

Graham and Smith (2004) collected historical productivity data on the concrete supply and in situ distribution for the reason of deriving a forecasting model by using Case Based Reasoning (CBR) principles. Chan and Kaka (2007) studied the factors of construction productivity in the United Kingdom by conducting a survey based on questionnaire aimed at both blue collar workers and white-collar managers. Tsehayae and Fayek (2016) studied and developed system model parameters by reviewing prior literatures. The data were collected from the field at 11projects over a span of 29 months. Activity models based on the relationship between construction labor productivity (CLP) and WSP (work sampling) were created, and their validity was tested using regression analysis for eight activities in the concreting, electrical and shutdown categories. The proposed system model was developed for concreting activity using the key influencing parameters in conjunction with WSPs. The results of the regression analysis indicate that WSPs, like direct work, are not significantly correlated to CLP and fails to explain its variance. Evaluation of the system model approach for the concreting activity showed improved CLP prediction as compared to existing approaches.

Even though, several researches has been done in the past due to complex variability of CLP influencing parameters and factors, increasing of complexity of construction projects and challenges in collection of data, there is a need to investigate the CLP .

1.3. Statement of the problem

Productivity can be defined in many ways. In construction, productivity is usually taken to mean labor productivity, that is, units of work placed or produced per man-hour. It is a ratio of production output to what is required to produce it. The measure of productivity is defined as a total output per one unit of a total input. According to (Hashem et al., 2000) the following equation can clearly explain of the so called labor productivity:

Labor Productivity = $\frac{\textit{unit of physical output}}{\textit{work hours}}$................Equation 1

In construction productivity, the output is usually expressed in cost of labour or man-hours. In Ethiopian construction industry, there is a lack of production rate standards for contractors to use as a reference for purposes of construction cost estimation. CLP has a significant impact on project costs, as on-site labour costs contribute between one third and one half of overall project costs (Fayek 2011).Construction labour productivity is situated in an environment that is more complex and unpredictable than the conversion process itself. The identification of the CLP parameters is a priority in order to accurately model a CLP, as they are made of various objective and subjective factors and practices (e.g., crew size, foreman skill in planning, complexity of task, quality of drawings, weather condition etc.). The parameters are also used to understand the cause and effect relation of the environment to the efficiency of the conversion process, represented in terms of efficiency measures like CLP. The major problem occurring in any construction project is the delays occurring during the project, which consequently affect the cost and the overall profitability of the project. In a way of making the construction projects more profitable, construction managers need to implement new strategies to improve labour productivity and this can be done if they have a clear understanding on the factors affecting the CLP and a model which helps them to now by how much it impacts the CLP. Resolving this issue can help to improve the overall performance of construction projects through the implementation of a model. In addition, it provides an up-to --date concept of loss of productivity measurement for construction productivity claims.

1.4. Research objectives

1.4.1. General objectives

The main objective of this thesis is to develop labour productivity improvement model for the Ethiopian construction industry.

1.4.2. Specific objectives

The specific objectives associated with the CLP model development are:

- ✓ Identify influencing factors and parameters of the CLP on construction project
  .
- ✓ Develop a local factor model to predict the CLP by using variables influencing parameters.
- ✓ Establish Alternatives strategies for improvement of the CLP.

1.5. Summary of the research

In this research, firstly factors and parameters influencing the CLP were identified by reviewing a number of literatures especially from developing countries of, the factors were then classified into four main factors such as management, labor/human, technological and external. Secondly, data was collected at Meles zenawi leadership academy for a period of 2 months, and each factor were quantified. Then, the CLP was calculated as a ratio of a daily production of a given crew to the recorded duration of the considered activity.. In this method, project site activities were monitored whereby the motivation, capacity to perform the job, leadership of the foreman, complexity of the task and clarity of the specification were quantified using likert scale.

The project management team was consulted to get reliable information on the crew members. Then, the different data were used to develop trends that helped us to develop a model for the study. The statistical data were used to analyze the positive or negative effect of selected factors and parameters influencing the CLP. Then, the data were analyzed using multiple regressions to model a crew level productivity subjected to a number of factors. Lastly conclusions and recommendations for future research work related to CLP are established.

1.6. Limitations

This research has several limitations. Model limitations are mostly related to the model's structure and parameter. Some of the limitations are listed as follows:

- In this study, there was a limited data because the project was supposed to be running 11 buildings at once but only four were under construction due to design change order which made the contractor to wait for the new design.
- This research only investigates the factors that have the most literature available about them. This limits the research from having various factors that may have severe effects on labour productivity.
- There may be several factors that are not included in the factor model, but may have potential to improve the productivity model for a task
- This study was crew based modeling , but the researcher was not allowed to manipulate the crew size and composition or their working days to have enough data which made some factors such as overtime , fatigue and crew composition factors measurement non-significant.

Chapter 2: Overview of the construction industry

2.1. Introduction

The construction industry contributes significantly to socio-economic development and creates employment opportunities in the country. However, there is a consensus on certain common issues that plague the construction industry in developing countries. The international studies have identified various best practices and recommendations for resolving such issues.

The review shows that generally the contractors and the overall business environment in developing countries is still at the development stage. Given the opportunity, they can overcome their inadequacies, but they cannot change the work environment. The challenges being faced by the industry in developing countries include insufficient education and training (lack of HR), absence of commitment from the government, lack of long-term vision and planning for the industry, ineffective budgetary procedures resulting in cost over-runs, fluctuations in work load, defective contract documents, corrupt contracting procedures, lack of protection against adverse physical conditions, payment related delays, problems of bonding and insurance, lack of adequate financial resources, restrictions on imports, foreign exchange constraints, unfair competition from state-owned contractors and consultants, non-availability of equipment and spare parts and miscommunication of information which are the key issues to boost the overall industry.

The construction industry, by nature, has many special problems and requirements (Hillebrandt, P M, 2000) .The importance of taking measures to improve the performance of the construction industry has now been recognized in several countries at various levels of socio-economic development. Dedicated agencies have been formed in many countries to administer the continuous improvement of the industry, although they have different objectives, responsibilities and levels of authority. In the UK, the Construction Industry Board is an industry initiative, whereas its counterpart institutions in developing countries are government agencies. They include the Construction Industry Development Board of Malaysia, the Institute of Construction Training and Development of Sri Lanka and the National Construction Council of Tanzania (Miles and Neale, 1991).

2.2. Ethiopian construction industry

According to the fifth annual report on the Ethiopian Economy published in March 2007 by the Ethiopian Economic Association, "**unemployment challenges and prospects**" being its thematic issues. In the report, the Current State of The Construction Industry has been chosen to be the thematic issue. In the report, the construction Industry has been identified as a thematic issue owing to a variety of considerations: first, the issue is timely; second the industry has been registering remarkable performance in recent years; and third, despite its importance in the overall economy, it has not been assessed comprehensively to a level that enables one to understand the industry and make policy recommendations ((AAE), 2007). But clearly, the country has developed huge infrastructure and urban centre's remarkable building construction activities.

Recently, the Manufacturing sector increased by 17.4 percent and constituted about 25 percent of industrial output. Construction industry, on the other hand, contributed more than half (70.9 percent) to industrial sector and expanded by 20.7 percent signifying the leading role the construction sector plays in terms of roads, railways, dams and residential houses expansion. (NBE (National bank of Ethiopia), 2016)

Sectors		2012/13	2013/14	2014/15	2015/16	2016/17
Growth rate	Crop	8.2	6.6	7.2	3.4	8.1
	Animal Farming and Hunting	5.2	2.1	4.7	-1.5	4.5
	Forestry	3.3	4.2	3.5	2.2	3.5
	Fishing	19.4	32.5	30.6	0.1	0.5
Share in Agriculture	Crop	69.8	70.6	71.1	71.9	65.3
	Animal Farming and Hunting	21.3	20.6	20.3	19.5	25.3
	Forestry	8.8	8.7	8.4	8.4	8.9
	Fishing	0.1	0.2	0.2	0.2	0.2
Growth rate	Mining and Quarrying	6.3	-3.2	-25.6	-3.3	-29.8
	Manufacturing	16.9	16.6	18.2	18.4	17.4
	Electricity and Water	10.0	6.8	4.5	15.0	11.4
	Construction	38.7	23.9	31.6	25.0	20.7
Share in Industry	Mining and Quarrying	11.0	9.1	5.7	4.5	1.1
	Manufacturing	33.6	33.4	33.0	32.4	25.0
	Electricity and Water	8.3	7.6	6.6	6.3	3.0
	Construction	47.1	49.9	54.8	56.8	70.9
Growth rate	Whole Sale and Retail Trade	10.1	17.7	12.3	8.2	7.6
	Hotels and Restaurants	19.1	26.6	29.6	15.6	11.1
	Transport and Communications	16.5	12.7	13.3	13.7	12.1
	Real Estate, Renting and Business Activities	3.9	3.9	4.1	3.7	4.1
	Public Administration and Defense	7.6	11.0	6.0	7.4	22.1
	Others*	5.2	8.1	7.3	7.5	7.4
Share in Service	Whole Sale and Retail Trade	33.9	35.3	35.7	35.6	34.6
	Hotels and Restaurants	8.6	9.7	11.3	12.0	5.4
	Transport and Communications	10.1	10.1	10.2	10.7	12.5
	Real Estate, Renting and Business Activities	18.4	16.9	15.8	15.1	10.9
	Public Administration and Defense	11.0	10.8	10.3	10.2	12.5
	Others*	18.0	17.2	16.6	16.4	24.2

Figure 1: Growth and Percentage Distribution of Major Agricultural, Industrial and Service Sub-sectors

Source: (NBE (National bank of Ethiopia), 2016)

From the supply side, the GDP growth in 2015/16 is explained by construction and the services sectors. The construction sub-sector contributed 2.1 percentage points to growth, while the manufacturing contribution relatively increased to 0.9 percentage points (world Bank , 2016).

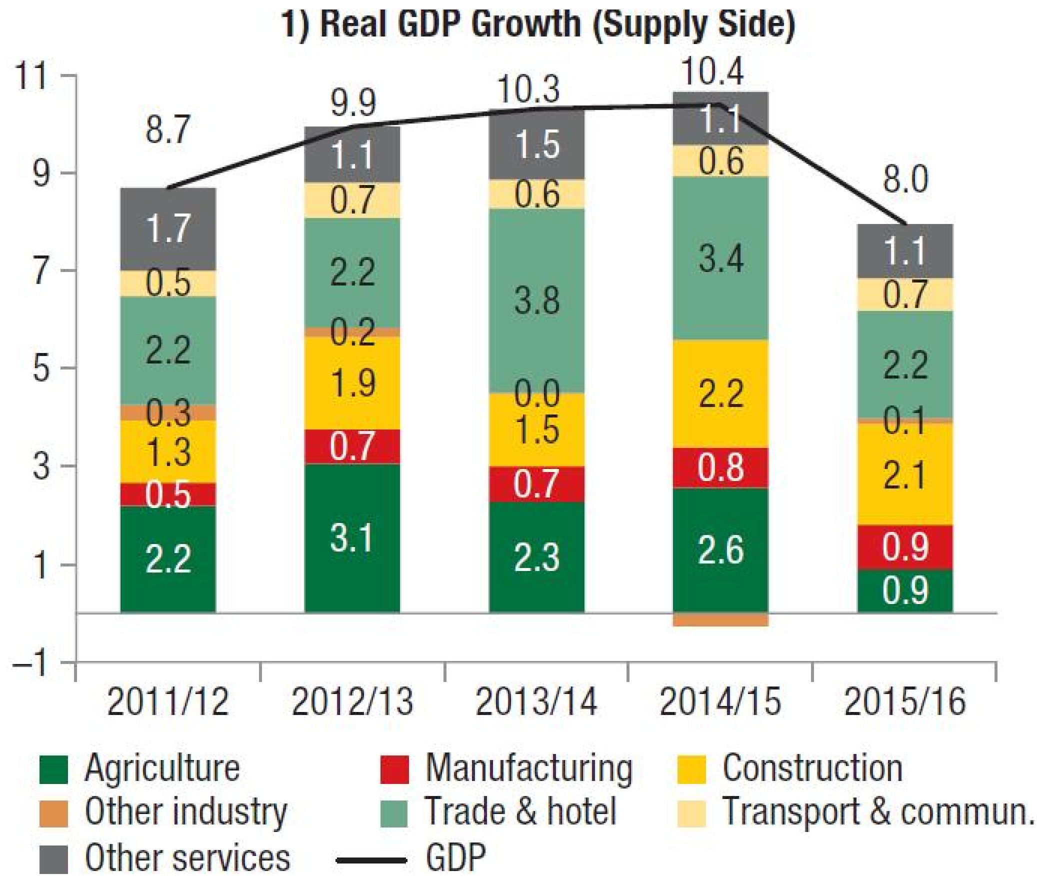


Figure 2: Industries contribution to GDP

Source: (World Bank , 2015)

However, According to (Tadesse Ayelew , 2016), Ethiopia is the second from the last followed by Mozambique. This indicates that the management practice in Ethiopian construction industry is even far behind from those poor performing developing countries in Africa. He revealed that the level of construction project management practice in terms of adapting general project management procedures, project management functions, tools & techniques are unsatisfactory.

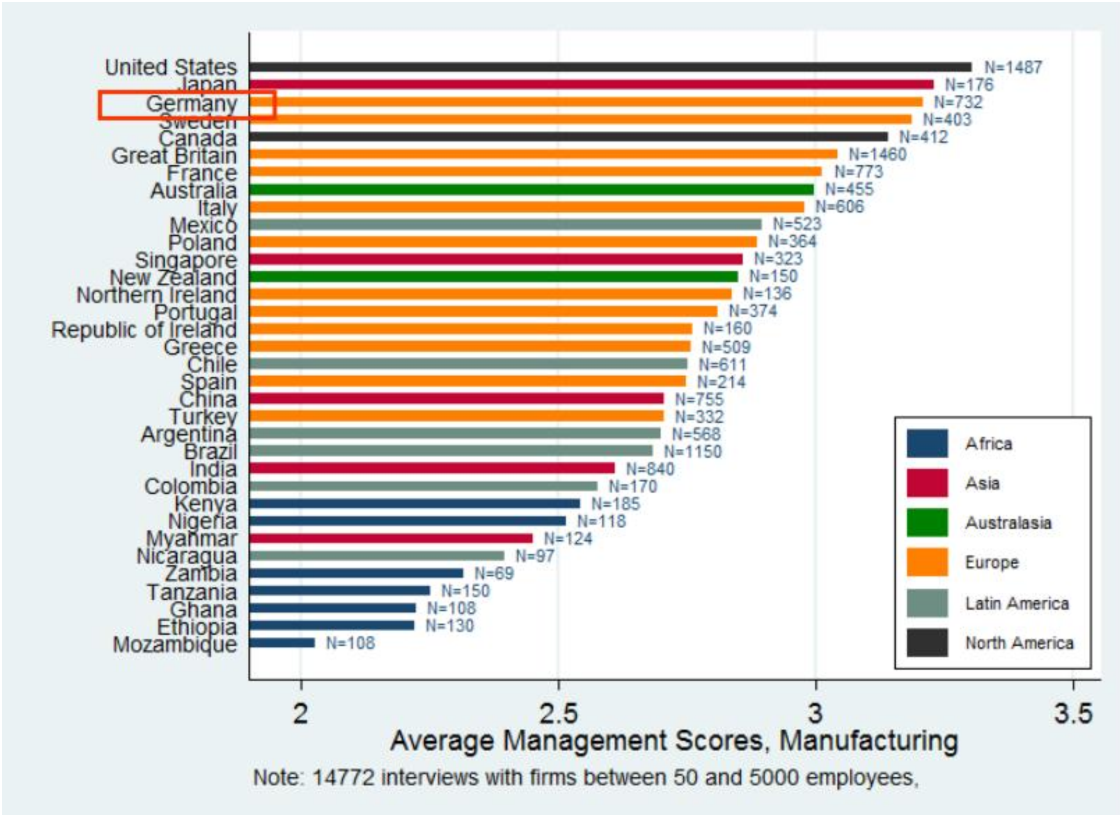


Figure 3: Average management score

Source: (M.Matters , 2014)

2.3. Structure of Ethiopian construction industry

The construction industry consists of various sectors. These are the building and residential development sector, civil engineering sector, professional services sector and self-building sector. The construction industry consists of deferent types and size of firms. These operate in the deferent sub-markets characterizing the construction industry. Construction firms must be registered and licensed in order to undertake any construction work in Ethiopia. The firms are classified according to size, expertise and financial capability by the ministry of work and urban development (MWUD). The self-building sector is characterized by an informal sector, consisting of informal groups that supply materials and labor. These informal groups are not licensed or registered. However, they employ a great number of people. The professional services sector consists of architects, civil engineers, electrical engineers, sanitary engineers, and mechanical engineers, quantity surveyors and surveyors who provided the design expertise.

The services of these consultants are not utilized in the informal and self-build sectors. There exists a great separation between the design consultants and the contractors.

This generates conflict in the construction process and results in project delays and cost escalations due to claims. However, we will be focusing on the contractors operations and merely their relations with the consultant in executing the work.

a. Contractors

According to Ministry of Works and Urban Development contractors in Ethiopia are categorized into four major groups including:

- General Contractors,
- Building Contractors,
- Road Contractors, and
- Specialized Contractors.

As per the Ministry of Works and Urban Development a General Contractor is a contractor that is allowed to engage in any types of construction contract works, a Building Contractor only in building construction, a Road Contractor only in road construction, and A Specialized Contractor in a special construction works other than those mentioned above such as water works, airport field construction...etc .Based on the data acquired from the Addis Ababa Bureau of Trade and Industry

Development the total licensed contractors in the city is 13, 557 as of June 2006. Out of the total contracting firms about 60% or 8,140 are general contractors and about 38% or

5,189 are building contractors. The number of specialized contractor and road contractors is insignificant contributing 1 % and 0.69% to the total number of contractors in the city respectively. Note that the current number of registered contractors is yet to be published.

b. Ethiopian labor and its characteristics

According to the World Bank, a modest shift in labor from agriculture to services and construction explains up to a quarter of Ethiopia's per capita growth. Agricultural employment declined from 80 to 77 percent between 2005 and 2013 but because agricultural labor productivity was so low, this shift gave rise to static efficiency gains as relative labor shares increased in construction and services where the average value added (salaries) of a worker is up to five times higher (World Bank , 2015) .

Over the last few years there has been a dramatic change in the way construction activity is being undertaken. This is not only in the form of new technology, but also in the way that construction projects are procured and managed. A substantial part of the construction work takes place in the informal sector of industry too. About 83% of the population lives in the rural areas. The buildings and other small infrastructure facilities for this major part of the population are constructed by the informal sector. The informal construction sector comprises of unregulated and unprotected individuals engaged in economic activities that include the supply of labour, materials and building components to the formal construction sector directly in response to needs of clients. It also includes works carried out by individuals and groups on a self-help basis without contracting.

In Ethiopia the sector has registered a remarkable growth, over the last 11 years there has been increased investment on the development and expansion of various infrastructure projects. Among the major developments construction of road infrastructure, real estate developments, and condominium housing projects are some of the examples. More specifically public infrastructure development projects by ministry of Education and Health and road infrastructure projects accounts the significant portion of the investment outlay on construction activities. Its contribution to the GDP at constant price has increased from Birr 2, 853,336,000 to Birr 8,185,747,000 at an average annual growth rate of 12.43%. Similarly the percentage share of the construction sector to GDP at constant price has increased from 4.5% in 2000/01 to 5.8% by 2009/10.

This sector is made of subcontractors that supplies materials. In Ethiopian construction industry, the recruitment of labor force is through the labor that has been working with the contractors for several years and they can call each other until they get the needed number.

2.4. Performance Constraints

The inefficient and deteriorated state of the construction industry with poor performance has detrimental effects to the development of the industry (Ministry of Urban Development and construction , 2012). Weaknesses, problems and constraints hampering the performance and development of the industry include:

- Low capacity and capability of the local contractors and consultants due to weak resource base and inadequate experience.
- Inadequate and erratic work opportunities, inappropriate contract packaging of works which favor foreign firms in donor funded projects, low public investment in infrastructure projects and over dependence on donor funding.
- Inefficient and non - transparent procurement Systems Corruption and financial mismanagement in public/private sectors.

- Lack of supportive institutional mechanisms in terms of financial credit facilities, equipment for hire and professional development.
- Unfavorable donor conditions which tend to marginalize local construction enterprises.
- Poor working environment, including low standards of safety and occupational hazards on construction sites
- Weak and non-facilitative policies and regulatory framework.
- Low productivity and quality Low technological base.

Chapter three: Literature review and research methodology

3.1.Introduction

In the construction industry, the research on the productivity is complex and multifaceted; therefore, different methods must be implemented to explore different perspectives for measuring or predicting construction labor productivity. Research in construction labor productivity has centered on the identification of factors that affect productivity, and quantifying the impact of such factors on productivity. Construction labor productivity, referred as output parameters (O), deals with the efficiency of labor crews converting inputs (land, knowledge, information, energy, materials, etc.) to outputs (project products) and input parameters (I) refers to a number of factors and practices (e.g. Crew size, crew composition, co-operation among craftsperson, location of work scope, complexity of task, weather condition, risk management practice, etc.), which either directly or indirectly influence CLP(Tsehayae Abraham, 2016).In this chapter, as a result of various qualitative and quantitative factors have been discovered, and various methods and limitations of the previous studies for predicting construction labor productivity have been presented. The literature is divided in two parts. The first part describes methods and models that have been used for predicting construction labor productivity. The second part describes factors that affect construction labor productivity.

3.2. Review of CLP Models

3.2.1. Factor model

The factor model consists of modeling the CLP by considering a number of parameters and factors that can affect the productivity. Different techniques to model the productivity can be used according to the data available. The factor model is a multivariate approach for modeling of construction labor productivity. The model is constructed in such way that the productivity is analyzed using statistical analysis by quantifying the effect of the identified factors on the CLP. Using the regression analysis, data from thirteen projects were compiled by (Sanders, S.R., and Thomas, R.H, 1993)to study factors affecting masonry productivity. However, all of the data compiled were not used to develop the model. The database including 465 samples were divided into two parts: Non disrupted or normal working days and, disrupted or abnormal working days. Abnormal conditions were usually results of disruptions such as congestion, lack of materials, and bad weather. Only normal working days consisting of 236 samples were used to develop the factor model. The following model was suggested:

PDP=$\alpha + \beta_1 + \beta_2 + \beta_3 + \omega + \Theta + \lambda_1 c + \lambda_2 c^2 + \lambda_3 c^3$ ... ...**Equation 2**

Where PDP is the predict daily productivity, α is a constant representing the standard conditions,β_1 is the work type coefficient, β_2 is the physical element coefficient, $\beta_3$is the design detail coefficient , ω is the construction method coefficient ,Θ is the weather zone coefficient ,λ_1,$\lambda_2$and λ_3 are the corresponding coefficient of the crew size terms and c is the crew size. Plots of factor model for temperature, humidity and crew size factors were given as a single factor model. To obtain the plot of factor model for temperature and humidity, their levels were varied, while rest of the factors was kept constant at their standard condition levels. The standard condition levels were defined by Sanders, and Thomas (1993). The plot of factor model for the crew size was obtained in a similar way, but this time crew size level was varied while the rest of the factors were kept constant at their standard condition levels.

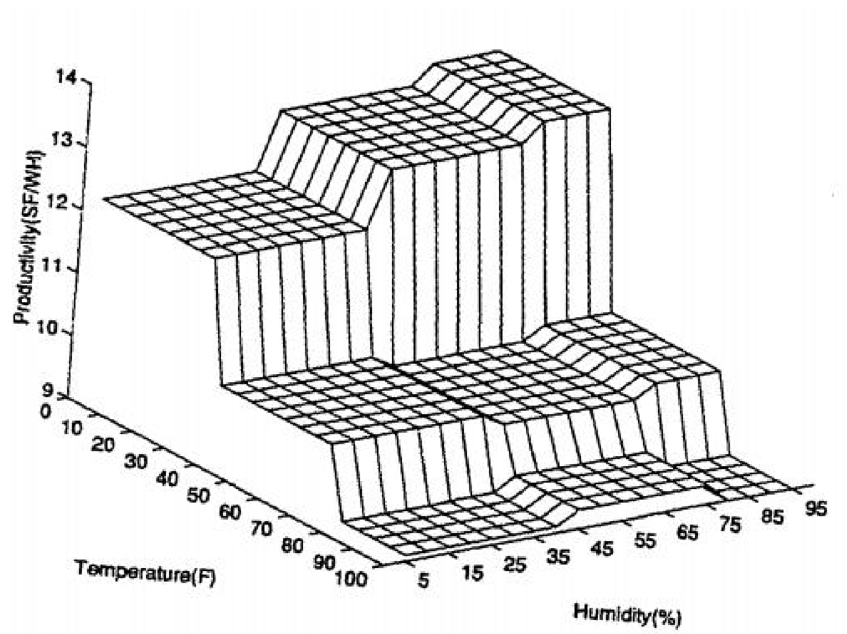


Figure 4: the plot for temperature and humidity with the other factors kept constant

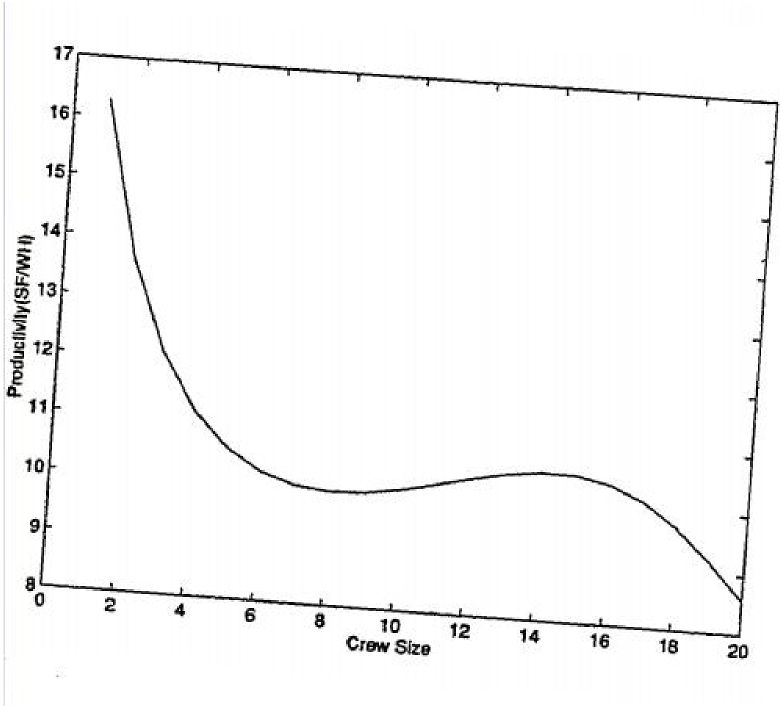


Figure 5: Plot of factor model for crew size with the other factors kept constant

Source: (Rifat Sonmez, 1996)

1. Regression analysis Model

In regression analysis, the CLP is modeled in such way that a graph is plotted by considering a single factor to quantify it impact on the productivity. The method of regression requires also the user to decide a priori on class of relationship to be used in modeling. Model fitting for construction labor productivity data requires quantification of the effects of factors on labor productivity and quantification of the interactions among the factors. In a multivariate factor model for modeling labor intensive crew-level productivity, it was argued that although factors affecting crew level productivity can lead to random or systematic, controlled or uncontrolled disturbances, they can be individually isolated to quantify the effects of each factor on ideal productivity (Thomas and Yiakoumis , 1987).

(Dunlop P.and smith , 2003) analyze productivity of concreting based on the data acquired from a sample of 202 concreting activities at three construction sites of a wastewater treatment facility in Scotland. The recorded data refer to the slabs, walls and columns, and the mean productivity per element amounts to 13.6m3/h. A regression model was proposed for predicting productivity of all elements: slabs, columns and walls. In Nigeria, the workforce productivity was examined (h/m3) based on the sample of 26 concreting positions of foundation walls, columns, slabs and beams, where concrete was transported using dumper tracks. Such form of transport, although limited to foundation concreting works, is very popular in this country because of the maneuverability of these vehicles and unloading method, and it is implemented on 50 % of construction sites. An average amount of concrete was 17.17 m3, and the achieved productivity amounted to 8.53m3/h (Olaoluwa, O., Adesanya, D.A.:, 2015) .

2. Neural network analysis Models

The neural network analysis has been used for decision making especially in the project scheduling but it has been also in use to predict the productivity in construction. Artificial neural networks consist of a large number of artificial neurons that are arranged into a sequence of layers with random connections between the layers (Tsoukalas, L.H, and Uhrig, R.E, 1997).

It can be arranged in different layers: input, hidden, and output. The hidden layer has no connections to the outside world because they are connected only to the input and output layers as shown in the fig.3 (Halpin., 2005). Neural network model developed has been able to achieve the objectives of this paper..(Sana Muqeem et al., 2011)used the neural network to model the production rate and values of concreting in columns have been calculated on site by observing seven different types of building projects. Factors influencing these rates such as weather, availability of material and equipment, location of project, site conditions and number of workers which are subjective in nature, have been recorded on scale at sites. To determine the individual effect and severity level of each factor severity indices have been calculated, they found the model accurate with acceptable error

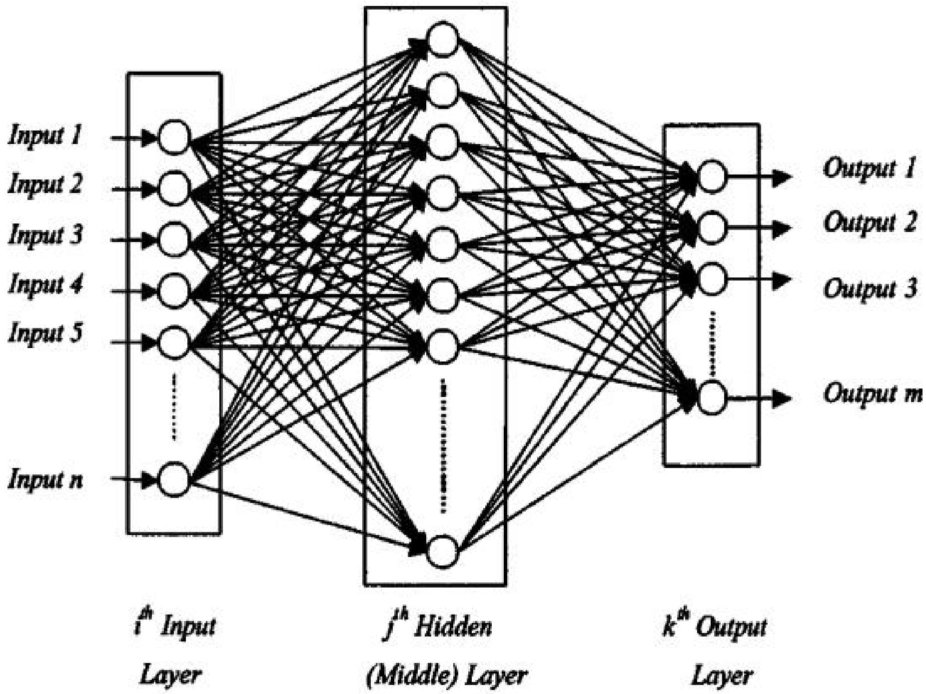


Figure 6: structure of artificial neural network (Halpin., 2005)

3. Adjustments Factors and repetitions model

Several studies in the past have been trying to quantify the factors affecting the construction labor productivity; they are in fact the base of the new succeeding methods of the CLP analysis. (Neil, J.M., and Knack, L.E, 1982) recommended use of adjustment factors to quantify the effects of these factors. Adjustment factors are generally values between zero and one, representing the effects of factors at various levels. The effect of a factor is reflected by multiplying the average productivity rate with the adjustment factor of the corresponding factor level. The factors were classified in terms of range as high, medium and low. However, the adjustment factors method does not define a quantified methodology for productivity prediction.

Coming to the repetition models, it was expected to improve the productivity by a number of repetitions by which the crew will be more familiar and skilled with the task. Repetition may also lead to improved equipment, crew, and material management, and development of more efficient techniques. The effect of repetition on construction labor productivity was modeled in several studies. These models are usually referred as learning curves. But this method cannot predict the CLP as they are of different affects and project dependent. The learning curve models developed by the Norwegian Building Research Institute and data of 44residential building activities were also included in the findings of the study.

4. Fuzzy inference systems

Because CLP modeling is a complex problem with limited data availability, and deals with a large number of subjective variables, CLP modeling is an exceptional target for another artificial intelligence technique: inference systems. Two types of inference systems are recognized: expert systems and fuzzy inference systems. While fuzzy inference systems are based on fuzzy logic and if-then rules; expert systems are based on traditional two valued logic systems (Tsehayae Abraham, 2016).In field of CLP prediction and estimation the fuzzy logic is not widely used but there few successful research. For example , sources have described predicting labor productivity using fuzzy expert systems (Oduba, A.O.,, 2002)estimating labor productivity using fuzzy set theory (Mao H., 1999)fuzzy logic to estimate productivity by including both qualitative and quantitative factors (Halpin., 2005)fuzzy expert systems to predict labor productivity of pipe rigging and welding(Fayek, A.R., & Oduba,, 2005), and fuzzy experts systems for construction labor productivity estimation (Muqeem, S., Bin Idrus, A., Khamidi, M. F., Siah, Y. K., & Saqib, M., 2012).

3.3. Factors and parameters affecting the CLP

3.3.1. Categories of CLP factors

In this study, the factors affecting the CLP are taken as independent variables and the CLP as the dependent variables .However; the factors and parameters affecting the CLP are classified into 4 groups of variables. Then, these productivity variables are labor/human, Management, technological and external. These four main factors are critical to productivity improvement. By modeling these variables that have a positive effect, and eliminating (or controlling) variables that have a negative effect will improve productivity .These variables represent the broad areas in which managers can take action to obtain better productivity (Heizer et al , 1990)

a. Labor

The quality of labor is very important to improve productivity. Three traditional variables for improved labor productivity have been (Heizer et al , 1990)

1. Basic education appropriate for an effective labor force;
2. Diet of the labor force;
3. Social overhead that makes labor available, such as transportation and sanitation.

In developing countries these three variables are very important however, in developed nation; the critical variable is maintaining and enhancing the skill of labor.

b. Capital

Human being is a tool using animals. Capital investment provides those tools. These tools can range from desk computers to complex machinery and new airports (Heizer et al , 1990). Production can often be accomplished with some trade-off between labor and capital. That is, if we want to build a road we can do so with crews of thousands using shovels or we can invest in earth moving equipment. The trade-off between capital and labor is continually in flux (Heizer et al , 1990).

c. Management

Management is a factor of production and an economic resource. It is responsible for insuring that labor and capital are effectively used to increase productivity. The arts and sciences of management include improvements made by technology and knowledge. Such improvements require a training and an education as well as dynamic organization (Heizer et al , 1990).

3.3.2. Overview of CLP's factors

In construction industry, the labor productivity is one the most difficult to control while managing a construction project. The input parameters are made up of several objective and subjective factors and practices which range from internal to external environments. Much research has been published about the factors that affect construction productivity. One of the greatest challenges facing the construction industry is its ability to attract and retain qualified and experienced workers. This is underscored by the fact that shortages of skilled workers continue to decrease in the construction industry. It is then necessary to implement a model through research in order to tackle this issue. In light of modeling the CLP, different factors and parameters need to be identified, classified and then compare their impacts on the CLP. Unfortunately, despite the large research in the area, a standardization of factors has not yet been achieved due to complexity of the data collection and the variety of the project. As highlighted earlier, there have been many efforts to identify and classify the factors that influence construction productivity, with a few attempting to establish the relative importance of the individual factors. The factors influencing construction labor productivity were identified from various perspectives. (Hashem et al., 2000)identified the top ten factors affecting the construction productivity in great Cairo through a structured survey questionnaire in 41 construction projects classified in two categories : residential and non-residential .(Brent G. Hicksona and Leighton A. Ellis b,, 2014) Investigated the factors affecting the construction labor productivity in Trinidad and Tobago using 42 predefined factors which were ranked by a help of questionnaire survey among the country's contactors association; the factors were classified into 4 categories: human/labor factors, management factors, technological factors and external factors. The lack of labor supervision was ranked first using the relative importance index.

Review of the literature indicated that there is no agreement among early researcher's on the factors affecting construction labor productivity. (Talhouni, 1990)cited delays, length of work days and gang composition as important factors influencing labor productivity. (Whitehead, R.C., 1990)argued that methods of working, buildability, bureaucratic constraints (contractual, tendering), weather and climate conditions and variations in working hours are among the important factors affecting productivity.(Hass, C.T., Borcherding, J.D., Allmon, E. and Goodrum, P. M,, 1999)cited ineffective management as the primary cause of poor productivity rather than an unmotivated and unskilled workforce. They argued that there is no doubt that management effectiveness ultimately determines profitability in most cases. (Allen, S. G,, 1985), stated that the main reason for poor productivity in the construction industry is due to absences and the unavailability of skilled labor. In a survey by (Adrian, 1987)during the construction of a power plant, it was reported that labor selection methods, skill shortages, unmotivated work force, delays and interruptions are among the main factors affecting productivity in construction projects.(Radosavljevic, M., and Horner, M.W.,, 2002) suggested that "labor intensive work, unique design, the number of factors affecting on-site work and other variables make the construction industry unstable in its performance". Here the labor intensive nature of the industry was recognized among the main factors, which suggest that more research focusing on improving labor productivity is required.(Mekides A., 2016) In her thesis, she identified and ranked factors affecting the construction labor productivity in Ethiopian industry where the shortage of materials and delays in decision making were ranked first and second respectively.(Tsehayae Abraham, 2016)Identified 169 factors classified in four categories like activity level input, project level input, organization level input, provincial level input, national level input and global level input; the data were collected at 18 construction projects for a period of 29 months.

Table a: Summary of Studied CLP factors

Details of the study	Key parameters
G.Allen(1985) Why construction industry is declining	Skilled labor, decline in the average number of employees per establishment, capital-labor ratio, percent union, average years of workers.
Hashem et al. (2012) Factors affecting labor productivity in building Project in Great Cairo	length of work day, equipment breakdown, lack of materials, lack of proper equipments, lack of proper tools, inadequate supervision skill, material type, large volume of work, quality required, and work complexity
Brent and Leighton (2013) Factors Affecting the Construction labor productivity in Trinidad and Tobago	the lack of labor supervision, unrealistic scheduling and expectation of labor performance, shortage of experienced labor, construction manager's lack of leadership skills, skill set of laborers, delay in responding to requests for information (RFI), payment delay, communication problems between site management and labor, rain and late arrival, early quitting, and frequent unscheduled breaks.
Tsehayea A.(2016) Developing and optimizing context specific and Universal CLP models	**Categories:** activity level input, project level input, organization level input, provincial level input, national level input and global level input.
Mekides A. (2016) A study of factors affecting the labor productivity on building construction project in Addis Ababa	Shortage of material, Delays in decisions making, Incomplete and Inaccurate drawings, Lack of follow up the work progress, Financial difficulties of the owner/Payment delay ,Incomplete facilities (water & power supply, and sanitary facilities, Inspection and

	Instruction delay, Lack of Motivation, Frequent damage of equipments and Change of work order/Variation

3.3.3. Cases studies in developing countries

Factors affecting the CLP can differ from a country to another, from a region to another. Different Case studies were then investigated in order to get a deeper understanding of the factors affecting labor productivity in different countries, and understand what might be the reasons behind these factors. In this research, we focused on the factors affecting the CLP mostly in developing countries as they have likely similar problems in their different construction industry. In Kuwait, the research done by (jarkas, 2012)has shown that the top ranked factors affecting labor are; clarity of technical specification, change orders during execution, coordination level among various design disciplines, lack of labor supervision, proportion of work subcontracted, and lack of construction management leadership. The results obtained from this research demonstrate that the technological group was ranked first with 70.69%. External factors were the least ranked group with 54.05%. In Turkmenistan, (Durdyeu , Serdar and Mbachu , 2011) found that his top 6 factors are lack of local experience labor, schedule pressure caused by government, working overtime, financial weakness of the contractor, rework, and inadequate financial policies of the government. It can be said that the top 6 factors in his research were different than the top ones ranked in Kuwait. For example, rework in Kuwait was ranked 16 amongst 45 factors; while it was ranked 5th amongst 20 factors in the study of (Durdyeu , Serdar and Mbachu , 2011)

Also lack of experienced labor was ranked 1st in Turkmenistan while only 22nd in Kuwait. Similar research was done in Southern Regions of India by (Soham,Mistry and Rajiv,Bhatt, 2013)in the research "Critical factors affecting labor productivity in construction projects. Misty used the same factors that were chosen by (jarkas, 2012) in his research done in Kuwait, but he only chose to survey the top 27 factors affecting labor productivity in Kuwait.

The research targeted 152 contractors and received a total of 51 responses, which is 30% of the required sample. The top ranked factors were payment delay, skill of labor, clarity of technical specification, shortages of material, motivation of labor and construction method. The Table below shows a comparison between the top 10 factors obtained from (Soham,Mistry and Rajiv,Bhatt, 2013) and how they were ranked in the study of (jarkas, 2012)

From the table above; there is a difference in ranking between the same factors in Kuwait and India. The researcher believes that the difference between South India and Kuwait in the ranking of the factors could be due to the financial strength of the contractors in Kuwait. Another reason is due to the high population of experienced and skill foreign laborers that work in Kuwait; it is very difficult to have shortage of experienced labor. Other factors such as payment delay are ranked very low due to the government policies that makes sure laborers get paid on time.

In Iran, (Zakeri, Mahmood; Olomolaiye,O. Paul; Gary D., 2010)have shown a different outcome than the one proposed by (jarkas, 2012)and (Durdyeu , Serdar and Mbachu , 2011)Between the 10 factors surveyed, low level of pay was ranked as number 1. Some of the top ranked factors were casual labor force, remote site and family problems, delay in payment, discontinuity of work, and job opportunity.

Combinations of financial and material factors were ranked top factors in the research undertaken in Malaysia by (Abdul Kadir et al., 2005)Material shortage at project site was ranked 1st amongst the 50 factors surveyed. It is followed by non-payment (financial problems) to suppliers, causing the stoppage of material delivery to site. They are then followed by change order by consultants causing project delay, late issuance of construction drawing by consultants, incapability of contractor’s site management to organize site activities, and late issuance of progress payment by client to contractor.

Kuykendall (2007) has carried out research in the USA on the key factors affecting labor productivity in the construction industry. He has chosen 12 factors, which were then distributed to 200 contractors from the ENR (Engineering News Record) top 400.

The survey gives a brief description of each factor and the contractor is asked to assign a weight to each of the factors based on his/her knowledge and past experience in the construction industry. It was found that the top factors were management skills, followed by schedule management, safety management, labor skills, labor motivation, and equipment management. It can be seen that the top factors affecting labor productivity are mainly management factors. In (Adamu K.J. et al , 2011)research “labor productivity constraints in the Nigerian Construction Industry”, (Adamu K.J. et al , 2011) have shown that low wage levels are detrimental to productivity and was ranked first followed by lack of material being instrumental to productivity, instruction delay contributing to low production, and absenteeism of gang members causing delay. These results are different than the ones found by (Olabosipo et al, 2011)in their research about factors affecting the performance of labour in Nigerian construction sites. (Olabosipo et al, 2011) showed that the top factors in his research are lack of training and retraining, poor communication, inclement weather, unfair wages, and lack of motivation. (Olabosipo et al, 2011) Factors show that training, communication, and motivation are the main human factors that affect labour performance. On the other hand, (Adamu K.J. et al , 2011) showed that lack of material and low wage were the main factors constraining labour productivity in the Nigerian construction industry. Although both of the research took place in Nigeria the results have shown different top ranked factors. This can be due to the fact that each researcher targeted a different sample with his questionnaire, with different factors.

Due to a high number of foreign labourers in UAE and Kuwait, the researcher assumed that all research done would have found an almost similar result. This is due to hot weather, approximately the same salary, same living conditions, same government laws and regulations. The results found in (Ailabouni,, 2012)research “factors affecting employee productivity in the UAE construction industry” has shown that the number 1 ranked factor was proper work timing, giving a balance between work, recreation and time with family, leadership skills of supervisors, salaries paid on time, technical training, reasonably well paying job and safe, and job security. The research of (jarkas, 2012)has ranked leadership skills of managers as 8th, skilled labour as 20th, while skilled labour was the 2nd in (Ailabouni,, 2012)’s research. Payment delayed was ranked 3rd in UAE, while it came 29th in Kuwait. Shortage of materials ranked 27th in Kuwait and 9th in the UAE.

In Gaza, (Enhassi et al, 2011)surveyed 83 contracting companies within the Gaza Strip, 33 of which were first-class contractors, 37 second class contractors, and 13 third class contractors. They received a total of 76 completed questionnaires showing that the top ranked factors affecting labor productivity in building projects in Gaza were material shortages, lack of labor experience, lack of labor surveillance, misunderstanding between labor and superintendents, drawings and specification alteration during execution, and payment delay. These were the top ranked factors among the 45 factors surveyed. Comparing the results with other Arab and Middle Eastern countries (Kuwait and UAE), it was found that (Enhassi et al, 2011) has reached different top ranked factors than (Ailabouni,, 2012)and (jarkas, 2012).The top two factors were material shortages and lack of labor experience, which were ranked 27th and 22nd amongst the 45 factors that (jarkas, 2012)has surveyed and was at the bottom towards the surveyed factors in the UAE. The sixth top ranked factor in Gaza was payment delay, and that was a common factor in both UAE and Kuwait since it was ranked in the first top 15 factors. This indicates there is a problem with payment delay in all three countries. It can be concluded from the research done in Kuwait, UAE and Palestine that although the three countries have a lot in common, such as traditions, culture, government funding and support, foreign labors, weather, similar salaries, similar laws and regulations, there is still a difference in the factors affecting labor in construction projects in each country.

(Alinaitwe et al , 2007) have conducted a research in Uganda of the “factors affecting the productivity of building craftsmen”. The respondents (Alinaitwe et al , 2007)targeted were required to use their experience to rate 36 factors which affect productivity with respect to time, cost, and quality. Henry’s research is very important, as it shows that Sub-Sahara Africa construction industry is labor intensive. They are exposed to wet and extremely hot weather conditions and the working environment is hazardous. The research was done through questionnaires given to project managers who are registered in the National Contractors Association, and a response rate of 53% was received. The results show that the top ranked factors according to cost, time and quality are incompetent supervisors, lack of skills of the workers, rework, lack of tools/equipment, poor construction method, poor communication, and stoppages because of work being rejected by consultants.

In Iran, (Ghoddousi et al, 2012)have found that the top rated factors are utilizing traditional construction methods instead of modern technology, inexperienced site managers who cannot handle challenges that arise in the field, lack of proper tools and equipment on-site, unskilled operatives who cannot perform the task and incapability of site manager to train workers to perform their jobs properly. These results were computed by surveying the 31 factors that (Ghoddousi et al, 2012)have found based on literature review. They showed that the results obtained indicate that the main problems identified in past research in Iran still have remained the “predominant obstacles” in the path of increasing productivity. In conclusion the research paper shows that lack of materials and tools are the two main groups that are declining productivity, and suggest that contracting companies should provide material supply and schedule for materials delivery for every project.

The results achieved from “Critical Factors Influencing Construction Productivity in Thailand” done by (Makulsawatudom, 2004) agrees with the results obtained by (Olabosipo et al, 2011)in Nigeria, (Ghoddousi et al, 2012) in Iran, and (Alinaitwe et al , 2007)in Uganda. The top factors in Thailand were lack of material, incomplete drawings, incompetent supervisors, lack of tools and equipment, absenteeism and poor communication. (Makulsawatudom, 2004) have offered suggestions in order to improve productivity by alleviating the effect of adverse factors. (Makulsawatudom, 2004) also suggested that improving labor productivity will make organizations more profitable, and increasing its chance of survival in the industry. These results are different from the ones obtained in New Zealand by (Durdyeu , Serdar and Mbachu , 2011) He sent 250 initial invitations, and he received only 37 responses (15% usable response rate). He targeted project managers, consultants, contractors, and subcontractors who had at least 15 years experience in the construction industry. 83% of the responses occupied high-ranking positions in their respective organizations as directors, managers, or associate directors.

Rating the factors was, therefore, from highly experienced subjects who had the authority to make important decisions about productivity in their respective organisations (Durdyeu , Serdar and Mbachu , 2011)argued that this added to quality and reliability of the feedback. He found that the top ranked factors were level of skills and experience of workforce, rework, and adequacy of method of construction, site conditions (access, sub-soil, and topography), level of motivation commitment, supervision performance monitoring and control.

In Indonesia (Soekiman et, 2009)research targeted small, medium and large companies. The authors wanted to see what factors related to labor productivity affect project schedule performance. They had broken the factors into four different groups; supervision, material, design, and equipment. After ranking all the factors in small, medium and large companies, (Soekiman et, 2009) came up with the top 10 ranked factors in all companies (small, medium and large). Some of the top ranked factors were lack of material, delay in arrival of materials, unclear instruction to laborers, labor strikes, financial difficulties of the owner, and high absenteeism of the laborers. (Mekides A., 2016)identified 53 factors that were selected by taking in to consideration their weights given by the previous researchers. The fifty three factors are summarized and categorized in to twelve groups according to their characteristic in order to help the respondents to easily understand. The respondents were requested to rate all the 53 factors with respect to their level of effect and frequency of occurrence.

The top ten factors rated by respondents with respect to their level of effect and frequency of occurrence are ranked by calculating using relative importance index (RII) and the impact of the two is also studies and discussed below. The top ten labor productivity influencing factors rated by their level of effect and frequency of occurrence are; 1)Shortage of material, 2)Delays in decisions making, 3)Incomplete and Inaccurate drawings, 4) Lack of follow up the work progress, 5) Financial difficulties of the owner/Payment delay , 6)Incomplete facilities (water &power supply, and sanitary facilities), 7)Inspection and Instruction delay, 8)Lack of Motivation, 9)Frequent damage of equipments and 10)Change of work order/Variation

The table below summarizes all the different case studies discussed in the literature review. The main aim of the table is to show each researcher's categorization of the factors, total number of studied factors, response received, and the top ranked factors in each country.

Country	Author/year	Respondents	Studied factors	Groups divided in	Top ranked factors affecting CLP
Nigeria	FagbenleOlasbosipo,Ogunde Ayodeji,andOwolabiJames (2011)	80	12	Not divided into groups	Lack of training and retraining, poor communication, inclement weather, unfair wages, lack of motivation, negative influencing factors
New zeland	SerdarDurdyeu,and JasperMabachu (2011)	37	56	Project finance • Workforce • Technology • Project Characteristics • Project Management • Unforeseen events • Statutory Compliance • External factors	Rework, level of skill and experience of the workforce, adequacy of method of construction, buildability issues, coordination and supervision, ground and site Conditions.

India	MistrySoham AndBhatt Rajv (2013)	51	27	• Technological • Human/labour • Management • external	Payment delay, skill of labour, clarity of technical specification, shortage of material, motivation of labour, construction method, and physical fatigue
Kuwait	AbdulazizM.Jarkas AndCamilleG.Bitar (2012)	147	45	• External • Technological • Human/labour • Management	Clarity of technical specifications, extent of variation/change order, coordination level among various design disciplines, lack of labour supervision, proportion of work subcontracted, design complexity level, and lack of incentive scheme
UAE	NabilAilabouni,KassimGidado,andNoel Painting(2012)	238	32	• Environmental • Organisation Work Policies • Group/Team Dynamics • Personal factors • Manpower	Proper work timing giving a balance between work and time with family, leadership skills of supervisors, salaries on time, technical qualified/educated for trade, reasonable well paying job, and safe secured job

				• Management • Environment	
Turkmenistan	SerdarDurdyev,Syuhaida Ismail,andNooh AbuBakar (2012)	124	23	Not divided into groups	Lack of local experienced labour, schedule pressure caused by government, working overtime, financial weakness of the contractor, rework, and inadequate financial policies of the government
Afghanistan	SebghatallahKarimi AndKassimGidodo(2010)	16	68	• External • Procurement • Manpower • Management • Design • Project related • Materials andtools	Security (crime, theft and disorder), corruption, poor scheduling and coordination, construction method, low quality of raw materials, and payment delay
Indonesia	A.Soekima,K.S.Pridadi,and Seomardi.B(2009)	63	17	• Supervision • Material • Execution plan	Lack of material, delay in arrival of materials, unclear instruction to labourers, labour strikes,

				• Design	financial difficulties of the owner, and high absenteeism of labourers.
Uganda	Henry MwanakiAlinaitwe,andJackson A. Mwaka(2007)	73	36	• Time • Cost • Quality	Incompetent supervisors, lack of skills of the workers, rework, lack of tool/equipment, poor construction method, and poor communication
Gaza	AdnanEnhassi,Sherif Mohamed,andZaid Abu Mustafa(2007)	83	45	• Manpower • Leadership • Motivation • Time • Materials/tools • Supervision • Project • Safety • Quality • External factors	Material shortages, lack of labour experience, lack of labour surveillance, misunderstanding between labour and superintendents, drawings and specifications alternation during execution, and payment delay

Malaysia	M.R.AbdulKadir,W.P. Lee AndM.S.Jafar(2005)	100	50	Not divided into groups	Material shortage at project site, non-payment to suppliers causing the stoppage of material delivery to site, change order by consultants causing project delays, late issuance of construction drawing by consultants, and incapability of contractor's site management to organize site activities
Thailand	ArunMakulsawatu DomandMargaret Emsley(2004)	34	23	Not divided into groups	Lack of material, incomplete drawing, incompetent supervisors, lack of tool and equipment, absenteeism, poor communication, and instruction time
Iran	MuhmoodZakeri AndPaul O.Olomolaiye(1996)	172	13	Not divided into groups	Lack of materials, weather and site conditions, equipment breakdown, lack of proper tools and equipment, inspection delay, and absenteeism

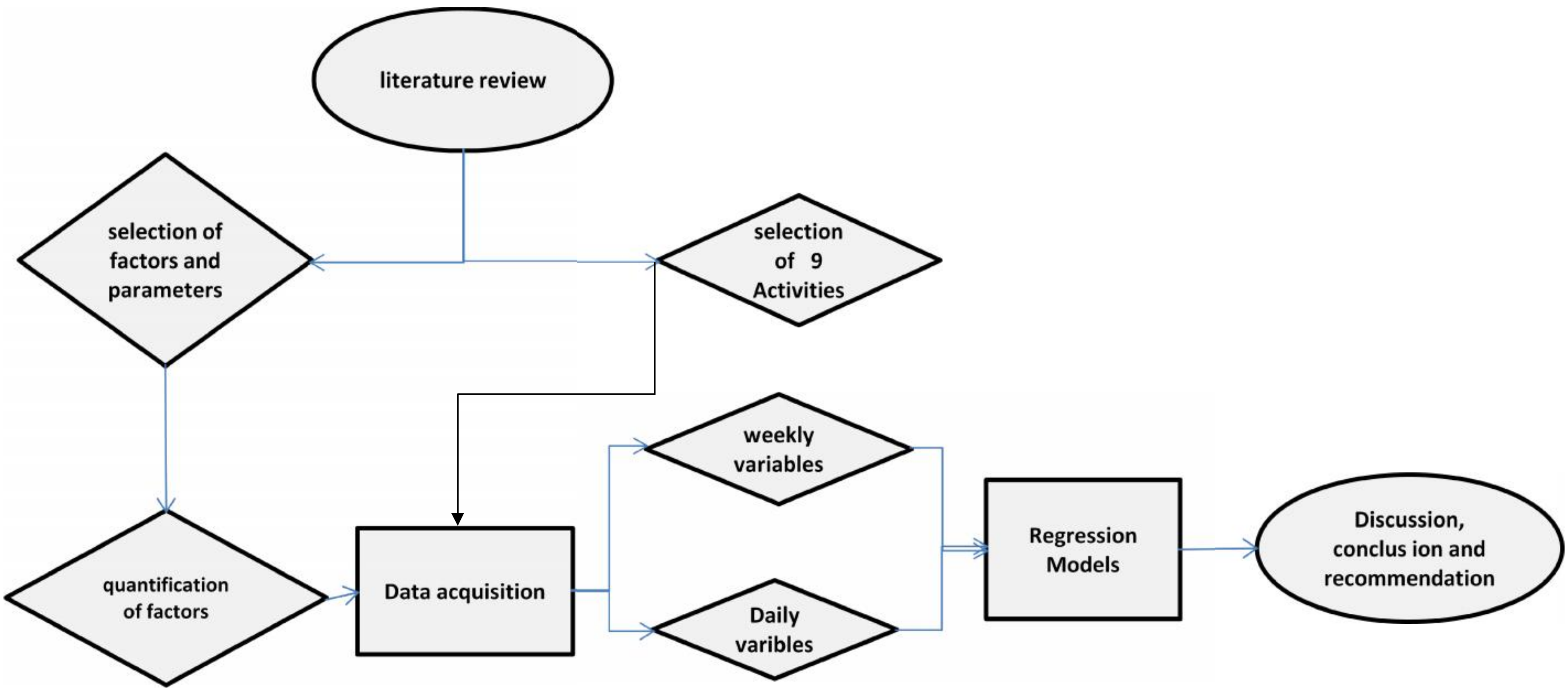
Ethiopia	Mekides A.(2016)	53	11	• Design and specifications • supervision factors • Material related factors • Equipment and technology factors • Labour related factors • Health and safety factors • project factors • organization /management • Stake holders factors • External factors • others	Shortage of material, Delays in decisions making, Incomplete and Inaccurate drawings, Lack of follow up the work progress, Financial difficulties of the owner/Payment delay , Incomplete facilities (water &power supply, and sanitary facilities), Inspection and Instruction delay, Lack of Motivation, Frequent damage of equipments and Change of work order/Variation

Table b: Summary of reviewed case studies

3.4. Research methodology

The factor model to predict the CLP in this study consists of the identification of factors affecting the CLP and their quantification, descriptive analysis, correlation and regression analysis of the data. In the identification of factors, an initial wide review papers from developing countries was performed and the considered factors were those repeatedly observed in different journals and articles. After the identification of the factors through literature review an analysis was done by calculating a number of statistics including means and standard deviations, and making several plots. The purpose of this stage was to identify the factors that might have an effect on production rate. Results of previous construction labor productivity studies were also used in combination with the data identification stage to define the initial regression model that has all the factors that might have a significant effect on the production rate for a task. The initial regression model for each task was a pure linear regression model without any interaction and nonlinear terms.

In this study parsimonious models were considered for modeling. A parsimonious model can be defined as a model that fits the data adequately without using any unnecessary parameters. The principle of parsimony is important because in practice parsimonious models generally produce better forecasts. (Pankratz, A., 1983)In the regression analysis stage the factors that did not improve the model significantly were dropped. This was done by dropping one factor at a time. T-statistic of the factor in the model, comparisons of closeness of fit, and prediction performance of the models with and without the factor, were the criteria used to determine the significance of the factor in the model.


literature review
selection of factors and parameters
selection of 9 Activities
quantification of factors
Data acquisition
weekly variables
Daily varibles
Regression Models
Discussion, conclus ion and recommendation

3.5. Identification of critical factors affecting productivity in building construction

From the above case studies , we concluded that the factors investigated from Ethiopia , India, Nigeria ,Turkmenistan, Indonesia, Uganda ,Gaza, Thailand ,and Iran have almost similar factors affecting their CLP ; here we can mention the lack of skilled labors and the shortage of materials . Based upon the Literature Review, this study extracts various factors affecting labor productivity in construction from the previous research studies. Some similar factors were merged together. Factors do not take into consideration any values, but it was merely focused on the factors which were investigated in the developing countries of the above case studies as matter of fact this study is about the factors affecting the building construction project in Ethiopia. The following table shows various factors affecting labor productivity in construction in extracted from previous studies in accordance to their frequency.

Table c: Frequent factors from the case studies

Factors	Frequency	Groups
1. Level of interruption and disruption	3	Management
2. Lack of leadership of the foreman	5	
3. Crew composition	2	
4. Use of overtime	3	
5. Crew size	3	
6. Extra works/rework	3	
7. Supervision of labor	4	
8. Shortage of materials	8	
9. Frequent damage of equipment	5	
10. Payment delay of the owner	6	Labor/Human
11. Fatigue of the craftsperson	3	
12. Skills of labor	4	
13. Crew experience	2	
14. Complexity of the tasks	2	Technological
15. Change of works order	3	
16. Clarity of technical specifications	5	
17. Working conditions	4	
18. Inspection and instruction delay	7	
19. Weather precipitations	3	external
20. Temperature	4	

1. **Level of interruption and disruption (F1):** it refers to any event or reason that delays the work which may disrupt the crew from performing the assigned work.
2. **Lack of leadership of the foreman (F2):** it is a measure of how the foreman cooperate or the crew members
3. **Crew composition (F3):** it the ratio of the number of carpenters or mason to the number of daily labor commonly called helpers.
4. **Use of overtime(F4):** it refers to the time added to the 8h hours that a craftsperson is supposed to work per day .it has been observed that the productivity in use of overtime has negative impact on the productivity .
5. **Crew size (F5):** The total size of the crew performing the actual task will have a direct effect on the amount of output.
6. **Extra works / rework (F6):** Extra work involves duties performed on a project that were beyond the original scope of the project. Extra work may indicate worse productivity achievements due to time spent on other activities and lower worker morale
7. **Supervision of labor (F7):** The supervision of labor consists of measuring or quantifying how the work is monitored within a particular crew**.**
8. **Shortage of materials(F8) :**it is the shortage or delay of material supply while executing the work can be happen due to several reason
9. **Frequent damage of equipment (F9)** : damage of the equipment affects the construction productivity as the crew won't be able to perform their work which will result delays in execution of the work before it get fixed or replaced
10. **Payment delay of the owner (F10):** Due poor financial problems and disagreement on valuation of work, and the impact delayed payment is delay in project progress which affects the schedule of work and leads to cost overrun and extension of time.
11. **Fatigue of the craftsperson (F11):** it refers to the fatigue of the crew members due to long work hours (overtime), extended work periods which leads them to mental and physical fatigue and this will lead to the low performance in the execution of the following tasks.
12. **Skills of labor(F12) :**the skills of labor refers to the ability of a labor to perform a work he is given in terms of time he takes to finish and the quality of the work he can deliver .
13. **Crew experience (F13):** it is the average years of experience the carpenters and daily labor working at a particular activity, has in the construction industry**.**

14. **Complexity of the task(F14):** it the measure of how the task or activity is difficult , this usually happen when the carpenter are not familiar with such kind of work or when the drawings are not clear
15. **Change of work order (F15):** is the work added or cancelled to the original work agreed in the contract due to design errors, modification of the design. it does affect in such way that the change has to go through process of approval and agreement between the client and the client
16. **Clarity of the technical drawings and specifications (F16))**: this usually happens when the drawings are not clear to the structural engineer or when there is relevant information which is missing on the drawings. This will require the engineers to consult the designers or the consultants
17. **Working conditions (F17):**Refers to the level of noise: number of equipment creating noise, level of intrusiveness of the created noise
18. **Inspection and instruction delay (F18):** construction is a complex task where each stage of construction has to be approved by the superintendents, but sometimes there is a lack of synchronization of tasks and decisions which affect the productivity.
19. **Weather precipitation (F19):** the weather can affect the construction labor productivity in such a way that it will cause disruption during the execution of work. it depends on how long it rained and what extent is the damage to the work

20. **Temperature (F20)**: Refers to the recorded temperature at 1:00 PM of the work day.

CHAPTER FOUR: DATA ANALYSIS, RESULTS AND DISCUSSION

4.1. Introduction

This chapter presents and discusses the project context, data analysis, findings, interpretations and presentation of the study in line with the research objective. Research objective is to establish how much the identified factors affect the construction labor productivity. These factors are level of interruption and disruption , lack of leadership of the foreman , crew composition ,crew size, Shortage of materials, Skills of labor , crew experience , complexity of tasks , clarity of technical specifications , working conditions , Inspection and instruction delay , Weather precipitation , temperature .

The variables are divided into categories as weekly and daily variables and regression model were developed for each.

4.2. Project context report

The project site Meles Zenawi leadership Foundation academy situated in the North East of Addis Ababa at about 25 km in a place commonly called Goro (at the opposite site of ICT Park). Meles Zenawi Leadership Academy was established for the realization of the sustainability journey of Ethiopian Renaissance.. The academy was established to host and train higher officials of the Federal republic of Ethiopia to lean with the ideas and directives of the country. The project worth 1.39 billion birr .The Academy's new offices will have nine blocks with heights ranging from 7 storeys to 11 storeys with 3 blocks for VIP. The campus will accommodate up to 4,000 students. The building will rest on four hectares of land. The building is expected to be completed within three years. Till to date, it has been two years since the construction started but it is still at its 6.81% of construction. According to the project manager, issues of incompleteness of the design and lack communication between the contractor and the consultant, most of the buildings have been revised .As result but the consultant did not yet submitted the final drawings.

The contractor has mobilized a batch plant and equipments that would work fully to supply for the nine blocks at once .However, due to the design change, blocks were delayed and the plants as well as equipments deployed are not working to their full efficiency.

4.3. Description of data

The data used in this research were collected to analyze the variability of construction labor productivity by considering 20 independent factors quantified and termed as follow:

a. Daily variables:

(F1) Level of interruption and disruption: the number of interruption or disruption per day

(F3) crew composition: the ratio of the carpenter or mason to daily labor or assistant labor in a crew or team

(F5)Crew size: real number of crew member working at the considered activity

(F8) shortage of materials: average waiting time of materials per day per crew

(F12) skills of labor: it was measured by taking the average of years of experience times the period of training per crew

(F14) complexity of the tasks : this was measure on a predetermined scale of 1-5 with 1 meaning many alternatives and well know ,2 as some alternatives and well known ,3 as few alternatives and known ,4 as few alternatives and unknown ,5 as very few alternatives and very unknown

(F16) clarity of technical specifications: it was measured on a predetermined scale of 1-5 with 1 as very poor clarity and very incomplete, 2 poor clarity and incomplete, 3 Fair clarity and fairly complete, 4 Good clarity and complete, 5 very good clarity, very complete

(F17) working conditions: it was measured on a predetermined scale of 1-5 with 1. No noisy equipment, very low intrusiveness, very normal voice level in conversation; 2. Few noisy equipments, very low intrusiveness, normal voice level in conversation; 3. Some noisy equipment, average intrusiveness, normal voice level in conversation; 4. many noisy equipment, high intrusiveness, high voice level in conversation; 5. too many noisy equipment, very high intrusiveness, very high voice level in conversation.

(F18) inspection and instruction delay: it is the real number of waiting time in minutes per day of the supervisor to approve or check for the performed task.

(F19)Weather precipitation: the rainfall on daily basis in millimeter. Note that the researcher was unable to collect data for this factor because it wasn’t raining during the data collection period.

(F20) Temperature: real number in Celsius recorded on daily basis

b. Weekly variables

(F2) lack of leadership of the foreman: the leadership skills of the foreman towards the labors , it was categorized into 4 : Autocratic , democratic , participative , goal oriented and situational

(F4) use of overtime: average real number of hours worked as over time in week time for a single crew

(F6) Extra works/rework: Average hours worked over a work which was not scheduled

(F7) Supervision of labor: weekly evaluation of the labor supervision on a predetermined scale of 1-5 with 1.Inadequate and very poor 2.Inadequate and poor 3.Adequate and fair 4. Adequate and Good 5. Adequate and very good

(F9)Frequent damage of equipment: real number of occurrence in a week

(F10) Payment delay of the owner: number of days that the labor have been delayed to have their monthly payment

(F11)Fatigue of the craftsperson: it is the ratio of the normal working hours per week (48hrs) to the actual worked hours in a week.

The Data were collected in a period of two months from September 2018 to November 2018. A total of nine activities were studied five from formwork activities (slab, column, beam, stairs and lift), three form concreting (column, slab and shear wall) and bar placement. The activities studied, description of the activities, and the number of total data instances used for the factor model analysis is presented in the following table.

Activity category	Activity	Activity description	Total data collected
formwork	slab ^{x}	formwork for floor	36
	column ^{x}	formwork for column	72
	beam ^{x}	formwork for beams	20
	lift	formwork for lift	24
	stairs ^{x}	formwork for lift	12
concreting	slab ^{x}	concrete placement for slab	16
	wall ^{x}	concrete placement for wall	4
	column ^{x}	concrete placement for column	18
rebaring	rebar ^{x}	placement of bars for different activities	24
Note : ^{x} Denotes the activities considered to develop a model			

Table d: Activities and number of data collected on each activity

However, the outliers analysis were conducted in IBM SPSS 24 statistical package at each activities using the box plots and cases were removed to find a well correlated model

4.4. Data analysis

4.4.1. Descriptive analysis

In this section, the minimum, maximum, mean and standard deviation of different factors and CLP considered were computed in the model. The values in the table 4 represent the mean and the standard deviation of each factor and CLP for its corresponding activity. For instance, for the slab formwork activity, the mean is 4.5 and 1.2352 for the crew size factor and CLP respectively with a standard deviation of 1.055 and 0.378 for the crew size and CLP respectively.

Table e:Mean and standard deviation of the influencing factors and the CLP values for daily variables

activity	Total data	unit	F1	F3	F5	F8	F12	F13	F14	F16	F17	F18	F20	CLP
1. slab formwork		m.sq	.94444 (.8926)	.8179 (.30331)	4.500 (1.0555)	8.0556 (5.1710)	4.4711 (2.0667)	5.3750 (1.9044)	1.94444 (1.0675)	3.5278 (.60880)	2.66667 (.79282)	7.5278 (5.1017)	18.6806 (.76667)	**1.23528 (.378172)**
2. column formwork		m.sq	1.33 (.964)	.8174 (.28416)	5.18 (1.304)	10.52 (4.755)	4.4276 (1.53128)	4.8455 (1.61549)	2.17 (1.048)	2.75 (.9000)	3.08 (.765)	10.31 (.765)	19.0972 (1.1886)	**.73529 (.15117)**
3. Beam formwork		m.sq	.5500 (.60481)	.6695 (.27437)	4.3000 (1.03110)	10.20 (3.39659)	5.1775 (1.59642)	5.5875 (1.57128)	1.8000 (.76777)	3.4000 (.75394)	2.5000 (.75915)	8.2000 (3.66649)	18.700 (.73270)	**.68885 (.295249)**
4. stair formwork		m.sq	.5000 (.52705)	.7160 (.30573)	3.1000 (1.28668)	12.0000 (4.26875)	4.7200 (1.87842)	5.0250 (1.99113)	1.6000 (.84327)	3.60000 (.69921)	2.70000 (.67495)	5.60000 (2.27058)	19.700 (1.49443)	**1.19810 (.330379)**
5.Lift formwork		m.sq	1.0417 (.90790)	.8829 (.34015)	5.5833 (1.47196)	9.4792 (3.02698)	5.3167 (2.91266)	6.0667 (2.25931)	1.8750 (.67967)	3.6250 (1.01350)	2.6250 (.64690)	6.2500 (2.65805)	19.1667 (1.16718)	**.80258 (.182573)**
6. Rebaring		m.cube	.6250 (.64690)	.8221 (.32980)	4.7083 (1.3666)	13.000 (4.66252)	6.5588 (2.19099)	7.3708 (1.91470)	1.4167 (.65386)	3.5000 (.65938)	2.7083 (.62409)	11.0833 (5.37237)	19.5000 (.97802)	**23.95863 (6.201640)**
7. column concreting		m.cube	1.31 (.873)	.3879 (.13105)	4.75 (1.438)	8.25 (3.337)	3.8547 (1.1475)	4.2063 (1.83138)	1.63 (.619)	3.31 (.793)	2.69 (.704)	7.63 (3.284)	19.3125 (1.1954)	**1.46931 (.68117)**
8.slab concreting		m.cube	.75 (.683)	1.0569 (.58943)	8.06 (5.131)	8.63 (4.5000)	4.2594 (106383)	4.8781 (1.31947)	1.69 (.479)	3.38 (.500)	3.06 (.680)	7.75 (3.256)	19.0625 (.777190)	**1.76838 (.36156)**
9. shear wall concreting		m.cube	.50 (.577)	.6650 (.38682)	6.00 (2.828)	7.000 (1.826)	3.5150 (.46867)	4.6875 (.62500)	1.75 (.5000)	3.75 (.975)	3.25 (.500)	10.25 (6.185)	18.000 (.000)	**1.02050 (.112340)**

Note: the values in the parentheses indicate the standard deviation

Table f: Mean and standard deviation of the influencing factors and the CLP values for weekly variables

Activity	Total data	unit	F2	F4	F6	F7	F9	F10	F11	F15	**CLP**
1.slab fowrmwork		m.sq	2.500 (.5345)	2.9375 (.67810)	21.87 (24.775)	3.3750 (1.302)	.3750 (.744)	00 (0)	.9413 (0.01356)	.500 (.75593)	**.9413 (0.0135)**
2.Stairs formwork		m.sq	1.5000 (1.00)	2.750 (.957)	16.25 (7.675)	3.00 (.816)	1.00 (2.000)	0.00000 (0.000)	.9450 (.01915)	2.0000 (1.82574)	**1.1093 (.27352)**
3.Lift Formwork		m.sq	2.50 (.535)	3.3750 (1.50594)	20.00 (29.88)	4.00 (.92582)	.8750 (1.125)	0.000 (0.000)	.9325 (.03012)	1.250 (.88641)	**.7843 (.027)**
4.column formwork		m.sq	3.000 (0.00)	4.25 (1.258)	1.000 (.81650)	3.25 (.95743)	1.000 (.8165)	0.000 (0.00)	.9150 (.02517)	.750 9.95743)	**.7095 (.01112)**
5.Column concreting		m.cub	3.00 (0.000)	3.000 (1.414)	0.000 (0.000)	4.25 (.5000)	0.000 (0.000)	6.000 (0.000)	.9350 (.01915)	.2500 (.5000)	**1.0595 (.0675)**

Considering the daily variables, the productivity was different for each type of formwork. The mean construction labor productivity (CLP) for the slab formwork activity was 1.23 and (.378) as the standard deviation. The column formwork has a mean of .735 and a standard deviation of 0.151. The beam formwork activity scored a mean of 0.688 and a standard deviation of 0.295. The staircase formwork activity has a mean of 1.19 and a standard deviation of 0.33 .The lift formwork activity has scored a mean of .802 and a standard deviation of 0.182.The bar placement activity has scored a mean of 23.59 and a standard deviation of 6.201. In the concreting activity we had 2 types of works, the column concreting with a mean 1.46 and a standard deviation of .681; the slab concreting which scored an mean of 1.76 and standard deviation of .361 and shear wall concreting with a mean 1.020 and standard deviation of 0.112.

In case of the weekly variables subjected to the CLP, we have slab formwork activity at a mean of 0.944 which is a bit lower than the daily one since it encounters different crew size and slab. The stairs formwork with a mean of 1.1093 and a standard deviation of 0.273 .The lift formwork scored the mean of 0.784 and a standard deviation of 0.027. The column formwork and concreting scored a mean of 0.7095 and 1.059 respectively and a standard deviation of 0.112 and 0.0675 respectively .And the mean tells the height of the average whereas the standard deviation tells us how spread out the heights around that average

3.3.2. Correlation and regression analysis

The correlations table displays Pearson correlation coefficients, significance values, and the number of cases with non-missing values. The Pearson correlation coefficient is a measure of strength of association between two variables. Pearson correlation coefficients assume the data are normally distributed. The values of the correlation coefficient range from -1 to 1. The sign of the correlation coefficient indicates the direction of the relationship (positive or negative).

However, the regression model was chosen taking into consideration to the availability of data. The study hypothesized that the decrease or increase in CLP is determined by the level of interruption and disruption , lack of leadership of the foreman , the crew composition , the use of overtime , the crew size , the extra work or rework , supervision of labor , the shortage of materials , frequent damage of equipment ,payment delay ,fatigue of craftsperson ,skills of labor ,crew experience, complexity of the tasks , change of works order ,clarity of the technical specifications , working conditions , inspection and instruction delay , weather precipitations and temperature . But note that the period of data collection, the weather precipitation was constant to zero .Then the following modified supply function was assumed for multiple regression

$$CLP_{daily/activity} = \beta_0+\beta_1F1+\beta_3F3+\beta_5F5+\beta_8F8+\beta_{12}F12+\beta_{13}F13+\beta_{14}F14+\beta_{16}F16+\beta_{17}F17+\beta_{18}F18+\beta_{19}F19+\beta_{20}F20 \quad \text{......Equation 3}$$

$$CLP_{weekly/activity} = \beta_0+\beta_2F2+\beta_4F4+\beta_6F6+\beta_7F7+\beta_9F9+\beta_{10}F10+\beta_{11}F11+\beta_{15}F15 \quad \text{......Equation 4}$$

Where:

$CLP_{daily/activity}$= the construction labor productivity which is the unit of work performed per man.hours by considering the daily working time as 8h per person per day

$CLP_{weekly/activity}$= =the construction labor productivity CLP for a week averaged to daily CLP

β_0Is the y- intercept

β_1 -β_{20}Regression coefficients

Pearson correlation and regression analysis for daily variables : Factors vs CLP

activity	Total data	unit	F1	F3	F5	F8	F12	F13	F14	F16	F17	F18	F20	Model Summary: R square	Model Summary: R Adjusted	ANOVA: F	ANOVA: sig.
1. slab formwork N= 36		m.sq	-.355*	-0.139	-.438**	-.467**	0.127	0.174	-.691**	0.180	-0.105	-.470**	0.136	0.776	0.674	7.564	.000[b]
			0.034	0.418	0.007	0.004	0.459	0.311	0.000	0.294	0.540	0.004	0.431				
2. column formwork N= 72		m.sq	-.391**	0.063	-0.228	-0.049	0.197	0.083	-0.062	.308**	-.397**	-0.080	-0.180	0.470	0.372	4.828	.000[b]
			0.001	0.598	0.054	0.682	0.098	0.488	0.606	0.008	0.001	0.503	0.130				
3. Beam column N= 20		m.sq	-0.398	0.170	-0.338	-0.168	0.116	0.182	-0.061	0.197	-0.019	-0.286	0.023	**Not significant**			
			0.082	0.473	0.145	0.478	0.626	0.441	0.799	0.406	0.936	0.222	0.924				
4. stair formwork N=10		m.sq	-0.105	0.617	-.878**	-.741*	0.532	0.551	-0.207	0.619	-0.021	-.888**	0.340	**Not significant**			
			0.773	0.057	0.001	0.014	0.114	0.099	0.566	0.056	0.953	0.001	0.337				
5.Lift formwork N=24		m.sq	-0.283	-0.129	-0.367	-.585**	0.158	0.224	-.475*	0.254	-0.189	-0.186	0.093	0.826	0.666	5.175	.004[b]
			0.180	0.548	0.078	0.003	0.462	0.293	0.019	0.232	0.375	0.385	0.665				
6. Rebaring N= 24		m.cube	-0.329	0.234	-0.051	-0.050	.776**	.718**	0.017	0.328	-0.261	-0.124	-0.225	0.827	0.669	5.228	.004[b]
			0.116	0.271	0.812	0.815	0.000	0.000	0.936	0.117	0.218	0.565	0.291				
7. column concreting N= 16		m.cube	-0.452	0.341	0.128	-0.031	0.457	0.457	-0.481	0.116	0.288	-.709**	-.546*	**Not significant**			
			0.079	0.196	0.637	0.910	0.075	0.075	0.060	0.669	0.279	0.002	0.029				
8.slab concreting N= 16		m.cube	-0.422	-0.140	0.085	-0.143	0.005	0.154	-0.181	0.029	-0.123	-0.284	-0.003	**Not significant**			
			0.103	0.604	0.755	0.597	0.985	0.570	0.503	0.915	0.651	0.287	0.992				
9. shear wall concreting N= 4		m.cube	0.370	0.894	-0.778	-0.928	0.532	0.535	-0.875	.996**	-0.448	-0.173	.[a]	**Not significant**			
			0.630	0.106	0.222	0.072	0.468	0.465	0.125	0.004	0.552	0.827					

*Correlation is significant at the 0.05 level (2-tailed).

Correlation is significant at the 0.01 level (2-tailed).

Table g: pearsoncorrelationa and regression analysis for the daily varibles

Pearson correlation and regression analysis for weekly variables : Factors vs CLP

Activity	Total data	unit	F2	F4	F6	F7	F9	F10	F11	F15	Model Summary: R square	Model Summary: R Adjusted	ANOVA: F	ANOVA: sig.
1.slab fowrmwork N=		m.sq	0.348	-0.365	-0.375	0.279	-0.237	.[a]	0.365	-0.499			Not significant	
			0.398	0.375	0.360	0.503	0.572		0.375	0.208				
2.Stairs formwork N=		m.sq	0.381	.987*	0.542	0.430	-0.449	.[a]	-.987*	-0.735			not significant	
			0.619	0.013	0.458	0.570	0.551		0.013	0.265				
3.Lift Formwork N=		m.sq	0.192	-0.334	0.086	0.278	0.079	.[a]	0.334	0.514			Not significant	
			0.648	0.419	0.839	0.505	0.853		0.419	0.193				
4.column formwork N=		m.sq	.[a]	0.869	.954*	-0.798	0.587	.[a]	-0.869	0.673			Not significant	
				0.131	0.046	0.202	0.413		0.131	0.327				
5.Column concreting N=		m.cub	.[a]	-0.279	.[a]	-0.350	.[a]	.[a]	0.142	-0.350			Not significant	
				0.721		0.650			0.858	0.650				

*Correlation is significant at the 0.05 level (2-tailed).

**Correlation is significant at the 0.01 level (2-tailed).

a.cannot be computed because at least one of the variables is constant

According to the table 6 in the slab formwork activity, the AdjustedR_{square} is called the coefficient of determination and tells us how the Construction labor productivity varied with the independent variables. The research findings indicated that there was a very strong negative relationship between the independent and dependent variables with an adjusted R square of 0.674 (67.4%). However, all the variables did not show a statistically significant variability in CLP value, it was explained by the crew size (F5) and the complexity of the work (F14). For the formwork activity, the adjusted$R_{square}$was a bit lower at 0.372(37.2%) with a negative relationship between the CLP and the influencing factors. However, the bar placement activity have shown a positive relationship of the influencing factors and the CLP with an adjusted R_{square} of 0.669 (66.9%). Lastly, the lift formwork has an adjusted$R_{square}$of 0.66(66.6%) and was affected by the factors such as the crew size (F5), shortage of materials (F8), crew experience (F13), skills of labor (F12)

By considering the daily factors, in the slab formwork activity F test has a significance level of 0.000<0.05, which indicates we reject the null hypothesis that β1- β20=0. The Regression sum of squares as a percentage of Total sums of squares (R_{square}) shows that 77.6 % of the variability of the CLP value is explained by the independent variables. In other activities like, the column, lift formwork and bar replacement F test has a significance level of 0.000,0.00,0.004 and 0.004 respectively all of them inferior to 0.05 , which indicates we reject the null hypothesis as well that β1- β20=0. The R_{square} shows that 47%, 82.6% and 82.7% respectively of the variability of the CLP value is explained by the independent variables

3.3.3. Factors affecting the labor productivity vs the CLP (units/mhrs)

The hypothesis was to see if the 20 factors from the literature can predict the CLP using the data collected from nine activities shown in table 1 at the construction site of Meles zenawi leadership academy. The general equation 1 and equation 2 for the multiple linear regressions were used for each of the nine activities. Among the nine activities considering the daily and weekly factors, only slab formwork, column formwork, bar placement and lift formwork were statistically significant.

The independent variable weather precipitations recorded constant values over the period and therefore could not be applied on the model to establish their effect on the CLP. The models incorporate only the coefficients of the remaining variables of the level of significance which produce p values less than 0.05.On elimination the variables with insignificant p- values from the model, we have the following equations.

1. **Slab formwork :**

   $\boldsymbol{CLP_{slab\ formwork}}$ **= 2.350-0.203 F5-0.193 F14**

For the slab formwork model, the crew size has shown a negative impact on the CLP. However, according to figure 7 the plot box of the mean and the crew size present a declining line from 3 the minimum size of crew and 7 the maximum size of a crew . Then, it doesn't mean that keeping the crew size low will provide high value of CLP but the construction manager should take a better decision according to the schedule or duration of the project. In fact, the increase in the crew size can cause an increase in the production rate but not in the CLP. The range for F5 (crew size) can be kept between 3 and 7.The complexity of the task in the slab formwork can be justified by skills required in levelling and at the beams level since both formwork slab and beam has to be erected at once

2. **Column formwork :**

   $\boldsymbol{CLP_{column\ formwork}}$ **= 1.49 – 0.052F1 – 0.03F5 +0.044F12 – 0.063F17 - 0.030F20**

In the column formwork, the level of interruption and disruption was explained by a number of interruptions during the execution of the activity. The skills of labor is well required in column formwork than in the slab formwork where in figure 14 the cubic coefficient of determination is about 63.5% , nevertheless according to table 4, the skills of labor presented a mean of 4.42 which is less than 4.47 presented by the slab formwork . The working condition and the temperature also slightly affect the to a range of [2-5] and [16-19]

3. **Lift Formwork :**

   $\boldsymbol{CLP_{lift\ formwork}}$ **= 1.507- 0.095F5 – 0.042F8 + 0.139F12 + 0.136F13**

The lift formwork has presented four factors, among which we have the shortage of materials and the crew experience with a coefficient of determination of 37.0% and 21.1% as univaraite factor on CLP (Appendix B)

4. **Bar placement**

   $\boldsymbol{CLP_{rebaring}}$ **= -13.085 + 4.175F12 + 5.060F16**

The bar works are positively affected with the skills of labor and the clarity of technical specification.

The crew size in figure 7, figure 9 and figure 16 in for the slab, column and lift formwork respectively has show a negative association with the mean CLP. The skills of the labor with the CLP plots in figure 11, figure 14 and figure 19 has also shown a positive association with a coefficient of determination of 3.9 %, 63.5 % and 26.8 % for column formwork, rebaring works and lift formworks activities respectively. However, the shortage of materials vs the CLP for the lift formwork activity has shown a negative relationship with a coefficient of determination of 37.0%.

3.3.4. Validation of the model

Model validity refers to stability and reasonableness of the regression coefficients, the plausibility and usability of the regression function and ability to generalize inferences drawn from the regression analysis. Validation is a useful and necessary part of the model building process. A good fit of a model to the data set is not an only goal of model validation but also its predictive accuracy of the model is how the model validates a new dataset. In this study, the regression models are developed; normality of the residuals (predicted minus observed values) has been verified using scatter plots of residuals so as to ensure the validity of the developed modes. In addition to that, the bootstrapping technique has been used as an internal validation method since we didn't have many that to perform the external validation method with training and testing data. The four models were validated. Bootstrapping replicates the process of sample generation from an underlying population by drawing samples with replacement from the original data set, of the same size as the original data set.

1. **For the slab formwork**

Table 8: Bootstrap model for slab formwork

Model	B	Bootstrap				
		Bias	Std. Error	Sig. (2-tailed)	BCa 95% Confidence Interval	
					Lower	Upper
(Constant)	2.350	-0.098	1.148	0.063	0.120	4.327
F5	-0.203	0.005	0.064	0.015	-0.376	-0.046
F14	-0.193	-0.016	0.084	0.031	-0.336	-0.085

The B value indicates the constant and the coefficient of statistical significant factors, the standard error is between the lower and the upper bias corrected accelerated. And the bias of each factor is negligible

2. Column formwork

Table 9:Bootstrap model for column formwork

Bootstrap for coefficients

Model		B	Bootstrap				
			Bias	Std. Error	Sig. (2-tailed)	BCa 95% Confidence Interval	
						Lower	Upper
	(Constant)	1.469	-0.029	0.404	0.001	0.701	2.158
	F1	-0.052	0.003	0.020	0.020	-0.097	-0.003
	F5	-0.030	-0.004	0.016	0.072	-0.054	-0.013
	F12	0.044	0.002	0.019	0.017	0.008	0.090
	F17	-0.063	-0.001	0.022	0.008	-0.102	-0.024
	F20	-0.030	0.002	0.014	0.042	-0.057	0.008

3. Lift formwork

Table 10: Bootstrap model for lift formwork

Model		B	Bootstrap				
			Bias	Std. Error	Sig. (2-tailed)	BCa 95% Confidence Interval	
						Lower	Upper
	(Constant)	1.507	-.001	1.588	.214	-1.974	5.095
	F5	-0.095	.010[b]	.052[b]	.121[b]	-.242[b]	.156[b]
	F8	-0.042	.001[b]	.049[b]	.300[b]	-.149[b]	.033[b]
	F12	0.139	.017[b]	.107[b]	.155[b]	-.335[b]	.163[b]
	F13	0.136	-.020[b]	.103[b]	.126[b]	-.016[b]	.224[b]

4. Rebaring

Table 11: Bootstrap model for rebaring

Model		B	Bootstrap				
			Bias	Std. Error	Sig. (2-tailed)	BCa 95% Confidence Interval	
						Lower	Upper
	(Constant)	-13.085	-6.009[b]	78.213[b]	.764[b]	-180.169[b]	117.663[b]
	F12	4.175	-.150[b]	3.270[b]	.191[b]	-3.222[b]	10.093[b]
	F13	5.060	-.590[b]	5.607[b]	.268[b]	-6.559[b]	16.473[b]

Chapter 4: conclusion and recommendations

1.1. Conclusion

The purpose of the study was to derive a model that can predict the construction labor productivity of concreting, formwork, re-baring activities at the construction project of Goro's Meles Leadership academy by using the factors affecting the CLP as independent variables and the CLP as dependent variables. The factors affecting the CLP are subjective and objective at the same time which makes them complicated to quantify .However the CLP is a very sensitive parameter to the profitability and success of a construction project; controlling the CLP can be a way leading to the success of a project. The variability of the CLP makes it one of the major sources of risks in construction it also made a racing arenas for researchers to develop an adaptable and accurate model to control the productivity .Through an extensive literature review, the researcher has categorized the factors into four main factors which are Management, Labor/human, technological and External factors. The main factors contain both objective and subjective according to their quantification method with the subjective factors measured using a likert scale. The researcher sought to confirm theoretical relationships between level of interruption and disruption , lack of leadership of the foreman, crew composition, use overtime, crew size ,rework, supervision of labor , shortage of materials, frequent damage of equipment ,payment of the owner, fatigue of the craftsperson ,skills of labor , crew experience ,complexity of the tasks ,change of works order , clarity of the technical specifications ,working conditions, inspection and instruction delay , temperature and the weather precipitation which were constant throughout the data collection period .All the parameters did not show a significant impact on the CLP and only the significant one were considered using a stepwise modeling .

From the findings of the analysis above, the conclusion is that there are significant relationship between the slab formwork productivity and the dependent variables crew size and the complexity of the tasks. The column formwork has also shown a negative significant relationship for level of interruption and disruption, the crew size, working conditions and temperature and has shown a positive impact with the skills of labour on the productivity. The lift formwork factor model presented a significant positive relationship with the crew experience and skills of labour; in addition to that it also includes two negative factored variables which are the crew size and the shortage of material. In the bar works , the regression analysis generated a model with a negative constant which made the it to have to strong positive variables which are the skills of labour and the clarity of technical specifications .

The weather precipitation variable had a constant data values for the period of the study and were therefore deemed to be of no use in the model. This variable was therefore exempted from the model and analysis.

What are the implications of these results for the CLP? Given our finding that the increase in crew size in slab, column and lift formwork activities has a negative impact on the CLP; however it doesn't implicate that using a limited number of labors in certain crew will give significant result in productivity rather the construction manager should compromise or balance with the schedule.

The modeling methodology of this research consists of three main points:

The first one was the identification and categorization of the factors affecting the construction labor productivity which was done by reviewing the literature from the developing countries; all factors were not considered however, the most frequent ones were considered.

The second one was the quantification of the factors and parameters influencing the CLP, the measurement of the input is a research and few selected methods were used in this research. The factors and parameters were either objective like crew size and crew composition or the subjective like complexity of the task.

The third point was to analyze the impact of these influencing factors and parameters where the models have been developed for each activity. However, in this research we only considered the factors and parameters that have presented significant impact on the activities. The variability of the CLP was tested using the scatter plots, correlations analysis and multiple linear regressions to derive a function.

Recommendations

To improve the productivity at the construction sites , proper planning should be established and followed by a strict monitoring of the activities .The model has shown that the clarity of technical specifications can contribute a lot in the bar erection and placement . The current study suggest that, holding other factors constant ; increasing the skills of labor and clarity of technical specifications are associated with a great increase in the bar works productivity . Thus, to improve the productivity and ensure success of a construction project, the management and labor/human main factors should be the areas of focus. Further, the construction managers should ensure the availability of materials, the proper communication with the consultants since it has been noticed that the level of interruption and inspection and instruction delay is highly due to the change works order.

Since the company has no proper program to train their workers, we find that most the labor has little skills to perform their work. Construction industry especially the ministry of construction should start encouraging the construction companies to have a program to train their skilled labors. Training programs should include on the job initiatives targeting those already working and help them with what they really need.

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Appendix A: Data collection sheet

Addis Ababa University
School of Graduate Studies
Institute of Technology
Data collection sheet

For master thesis in construction management

A factor model for predicting construction labour productivity in building Project: A Case study of Meles leadership academy construction project.

Researcher: Eng. Kwizera Arnaud

Supervised by: Dr. Abraham Asseffa

Partial fulfilment of the requirements for the degree of
Master of Science in Civil engineering

Addis Ababa, Ethiopia

2019

Productivity data sheet

Block		Activity		Date :

Crew Tag	Productivity code		Location	crew size	crew composition		Man-hours			unit
	Activity code	Task code			CRp	DL	work Time R	work Time OT	Total man-hours	
crew 1										
crew 2										
crew 3										
crew 4										

Quantification of factors and parameters

Crew	1	Date :		Block :		Data collector	

Main factors	Factor ID	Factors	scale of measure	Data source	Data value	Factor/Range of Value	predetermined ratings /Description
1. Management	F1	Level of interruption and disruption	level of interruption or disruption/day	data collector		range :recorded (min,max)	the number of delays events due to any reason
	F2	lack of leadership of the foreman	Autocratic,Democratic, participative,Goal oriented and situational	data collector		range :recorded (min,max)	
	F3	crew composition	Proportion (Ratio Journeyman to Apprentice)	data collector		range (0-1)	values of each case understudy
	F4	use of overtime	real avarage over time/week	data collector		range (min,Max)	
	F5	crew size	real number of a crew members	data collector		range :recorded (min,max)	values of each case understudy
	F6	Extra works /rework	average number of hours worked on extra work/week in minutes	data collector		range : recorded (min,max)	find attached in Appendix (F6)
	F7	supervision of labor	1-5 predetermine rate	data collector		range (1-5)	1.Inadequate and very poor 2.Inadequate and poor 3.Adequate and fair 4. Adequate and Good 5. adequate and very good
	F8	Shortage of materials	average waiting time in min/week	data collector		range :recorded (min,max)	values of each case understudy
	F9	Frequent damage of equipment	Real number of occurrence /week	data collector		range :recorded (min,max)	values of each case understudy
	F10	Payment delay of the owner	real number in days delayed /week	data collector		range :recorded (min,max)	values of each case understudy
2. Labor/Human	F11	Fatigue of craftsperson	total weekly worked hrs/regular work hours	data collector		range :recorded (min,max)	values of each case understudy
	F12	Skills of labor	average years of experience (years)X trainings /crew	data collector		range :recorded (min,max)	values of each case understudy
	F13	crew experience	average years in number of crew's experience	data collector			values of each case understudy
3. Technological	F14	complexity of tasks	1-5 predetermine rate (appendix)	data collector		range 1-5	1.Many alternatives and well known 2.Some Alterternatives and well known 3. few alternatives and known 4. Few alternatives and Unknown 5. Very Few Alternatives and unknown
		Change of works order	Real number of occurrence /week	data collector		range :recorded (min,max)	values of each case understudy
	F16	clarity of technical specifications	1-5 predetermine rate	data collector		range :recorded (min,max)	1. VERY POOR Clarity, VERY Incomplete; 2. POOR Clarity, Incomplete; 3. FAIR Clarity, FAIRLY Complete; 4. GOOD Clarity, Complete; 5. VERY GOOD Clarity, VERY Complete
	F17	working conditions	1-5 predetermine rate	data collector		Range :1-5	1. NO Noisy Equipment, VERY LOW Intrusiveness, VERY NORMAL Voice Level in Conversation; 2. FEW Noisy Equipment, VERY LOW Intrusiveness, NORMAL Voice Level in Conversation; 3. SOME Noisy Equipment, AVERAGE Intrusiveness, NORMAL Voice Level in Conversation; 4. MANY Noisy Equipment, HIGH Intrusiveness, HIGH Voice Level in Conversation; 5. TOO MANY Noisy Equipment, VERY HIGH Intrusiveness, VERY HIGH Voice Level in Conversation
	F18	Inspection and instruction delay	real number of waiting time(min)/day	data collector		range :recorded (min,max)	values of each case understudy
4. External	F19	Weather precipitation	rainfall in mm	data collector		range :recorded (min,max)	values of each case understudy
	F20	temperature	real number in °c	data collector		range :recorded (min,max)	values of each case understudy

Legend: Daily data (yellow) weekly data (grey)

Appendix B: factors and parameters affecting CLP versus CLP (scatter plots)

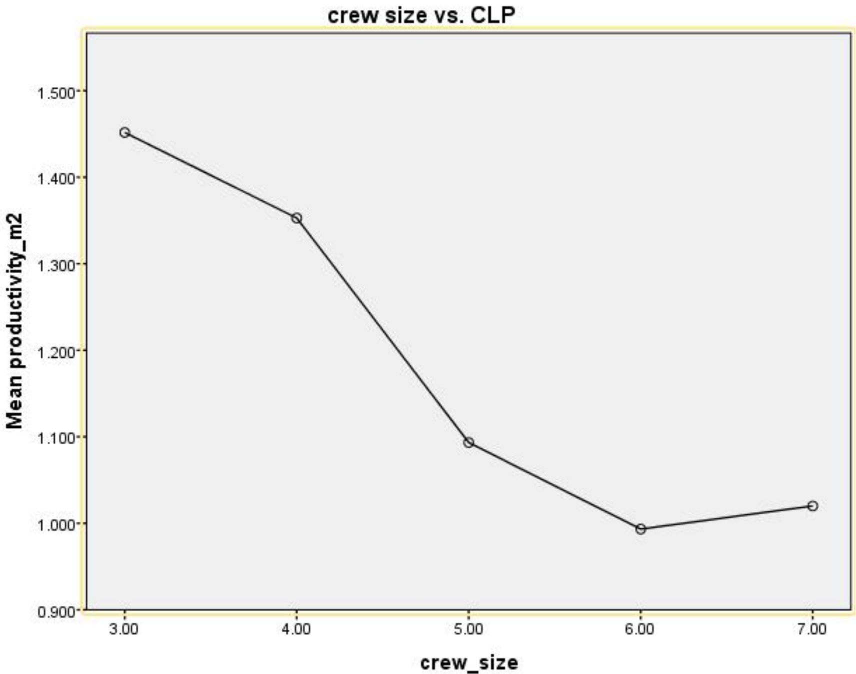

Figure 7: crew size vs CLP for the slab formwork activity

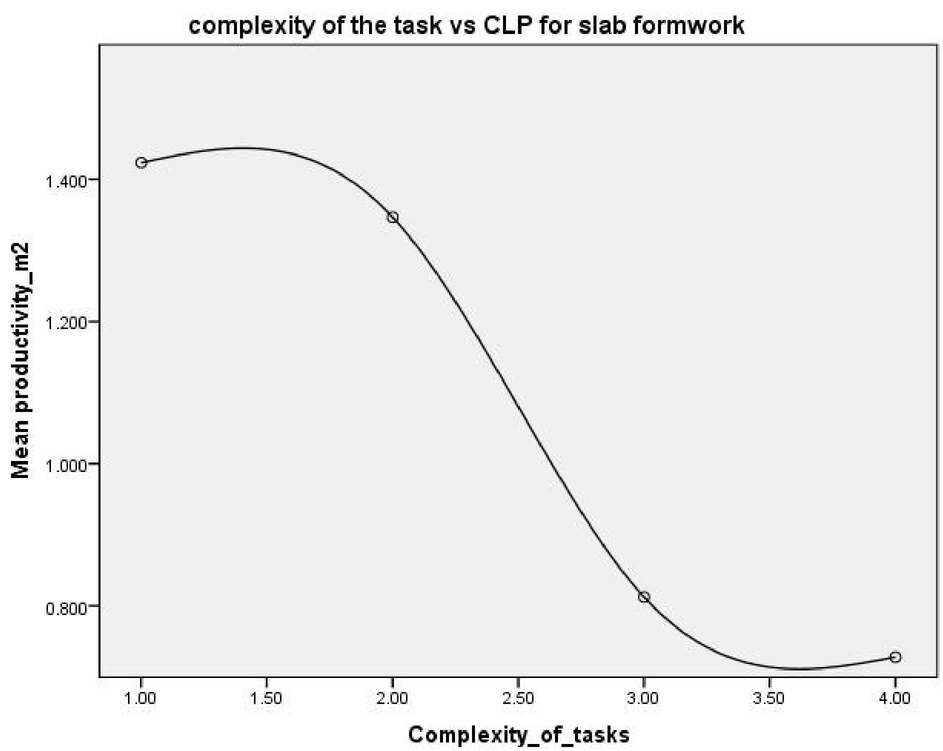

Figure 8: complexity of the task vs CLP for slab formwork

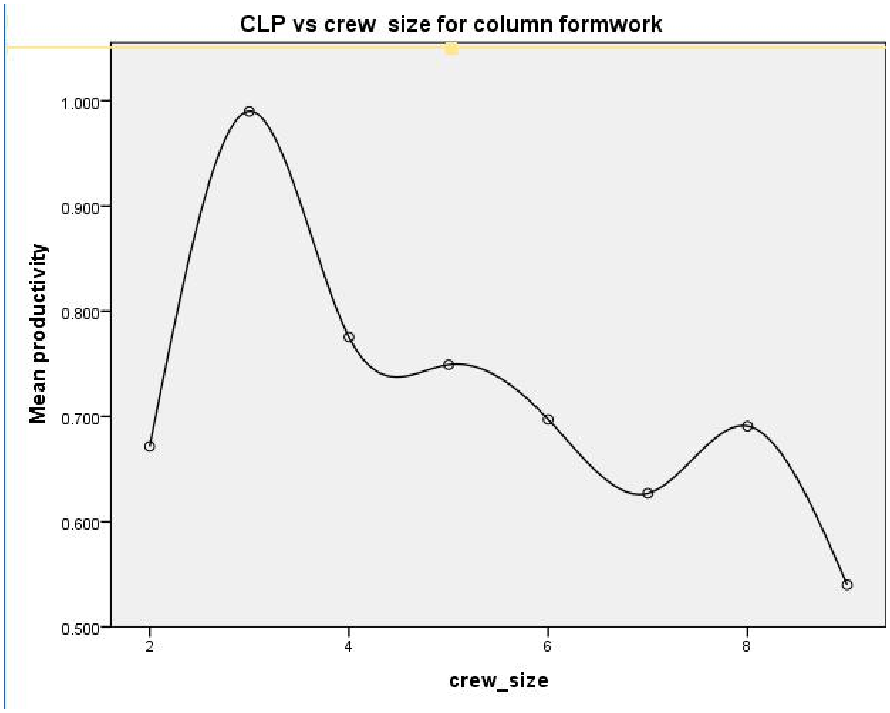

Figure 9: CLP versus the crew size for column formwork activity

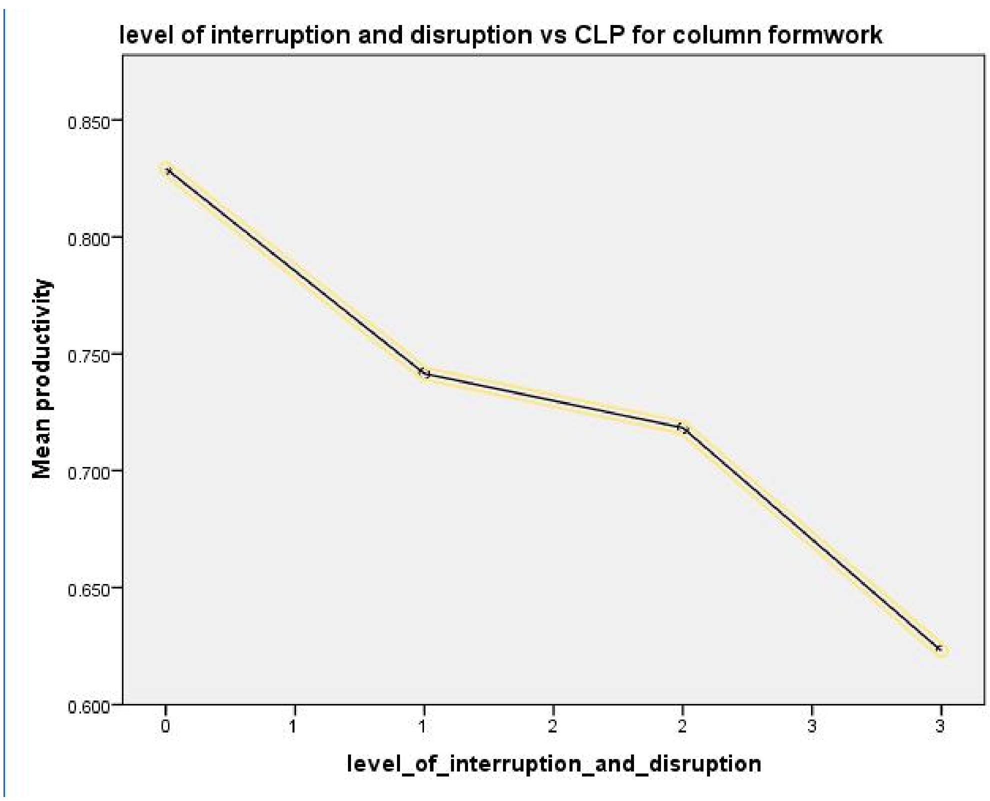

Figure 10: level of interruption vs CLP for column formwork activity

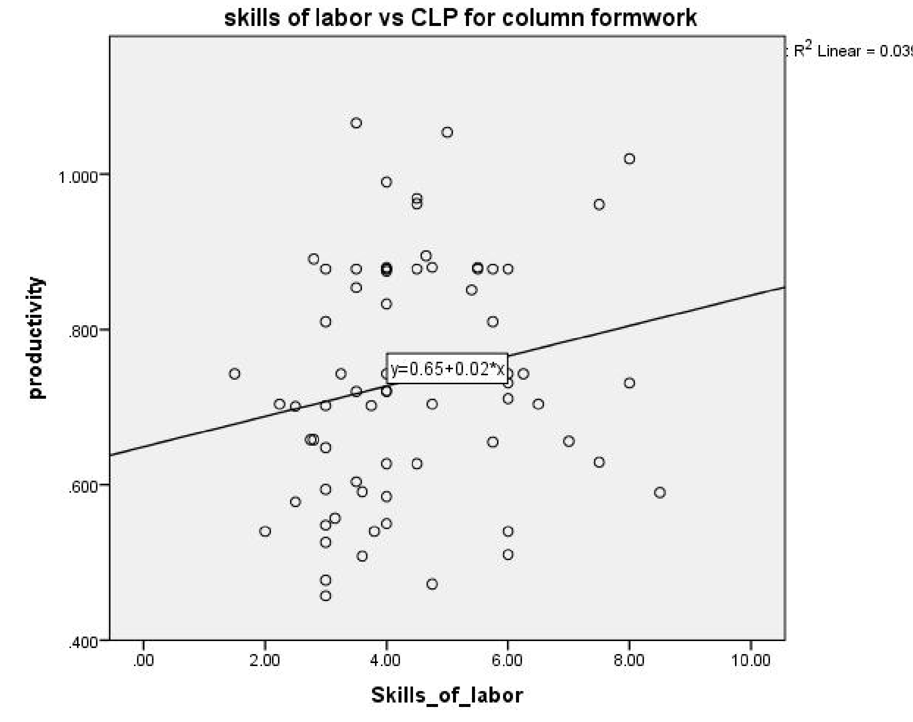

Figure 11: Skills of labor vs CLP for formwork activity

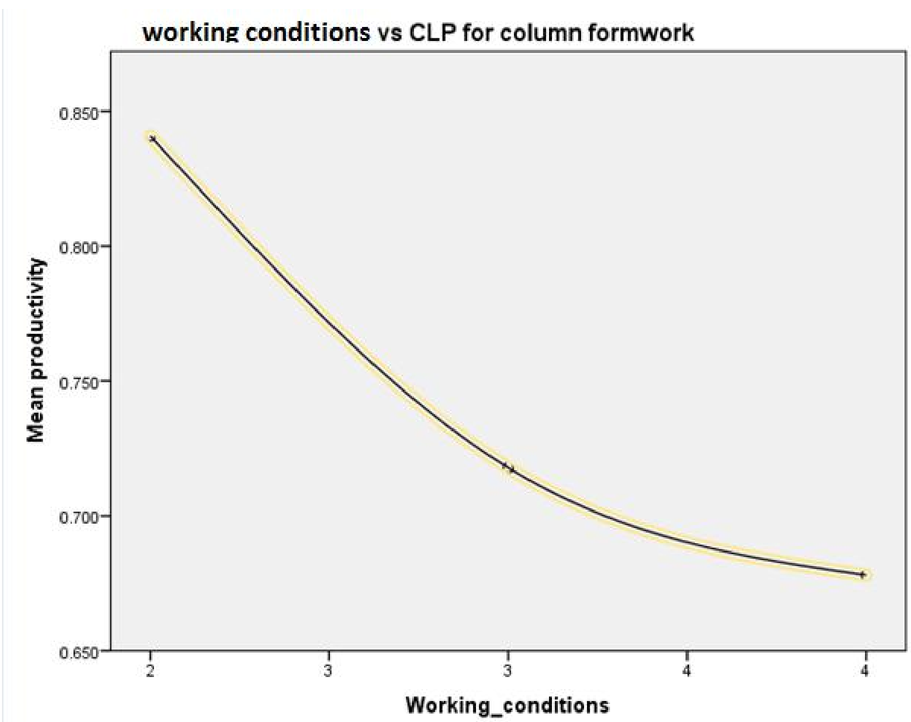

Figure 12: Working conditions vs CLP for column formwork

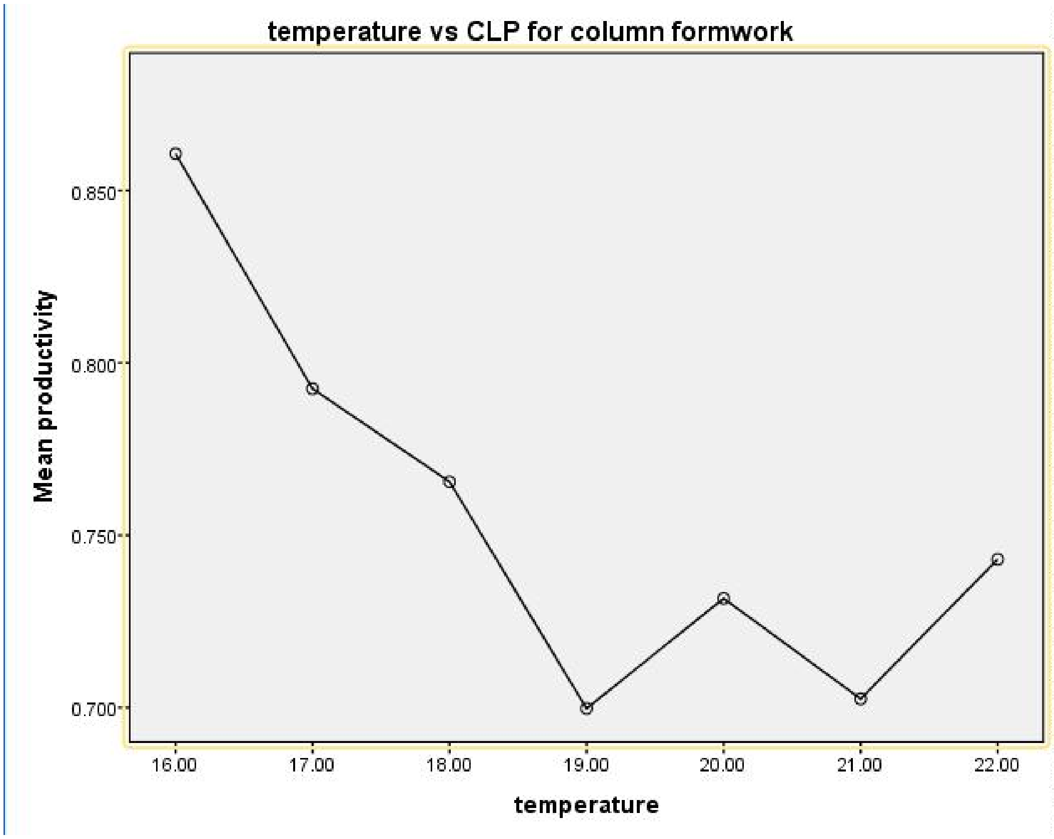

Figure 13: Temperature vs CLP for column formwork activity

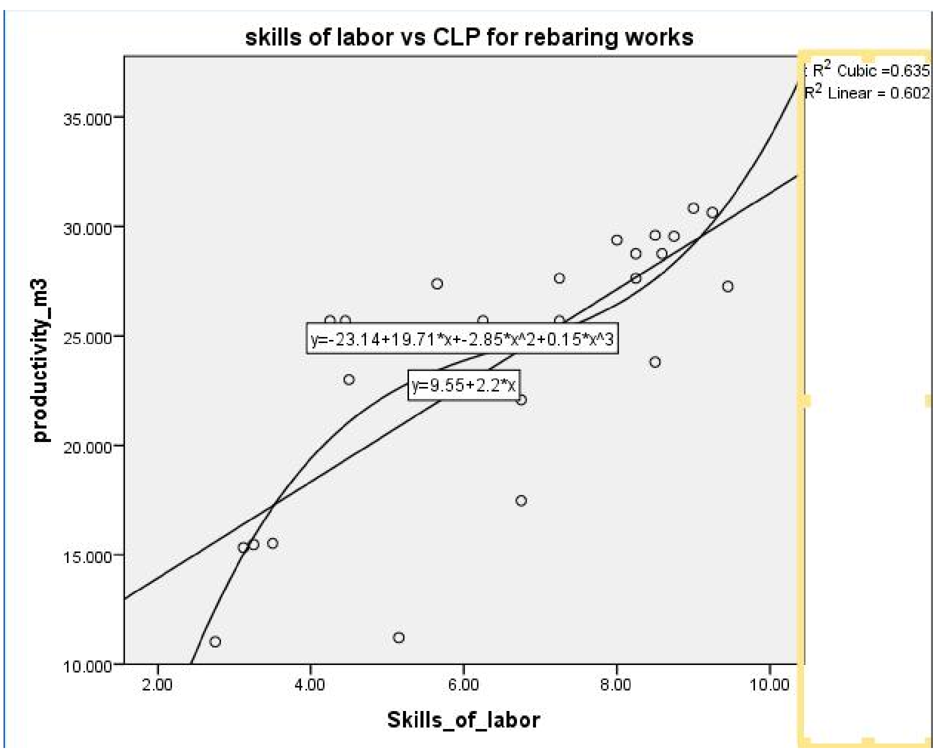

Figure 14: Skills of labor vs CLP for rebaring activity

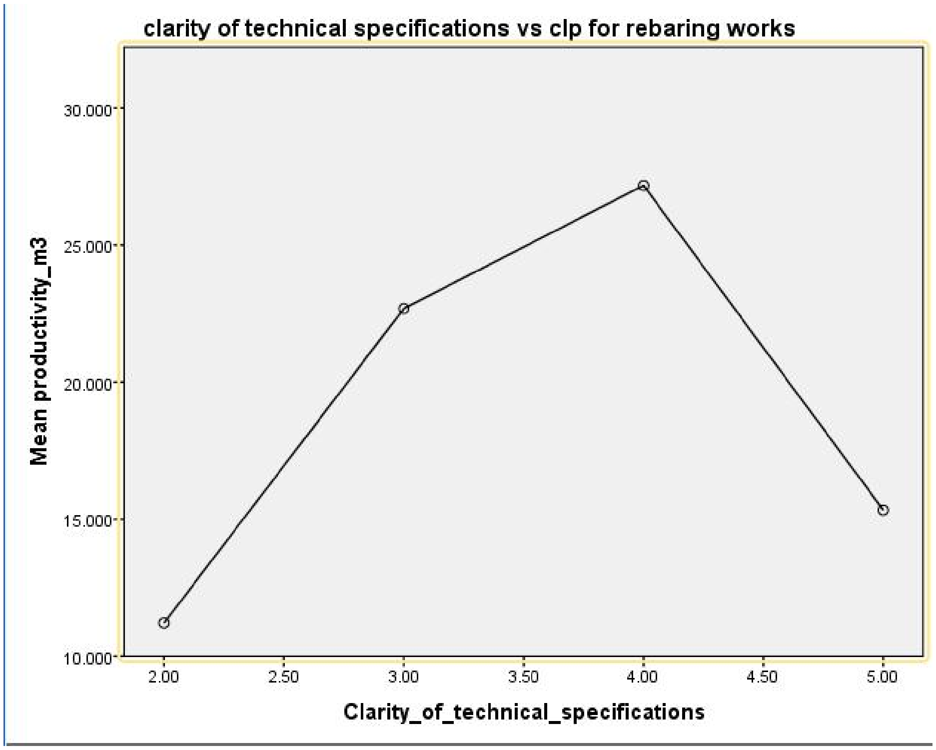

Figure 15: Clarity of technical specifications for rebaring works activity

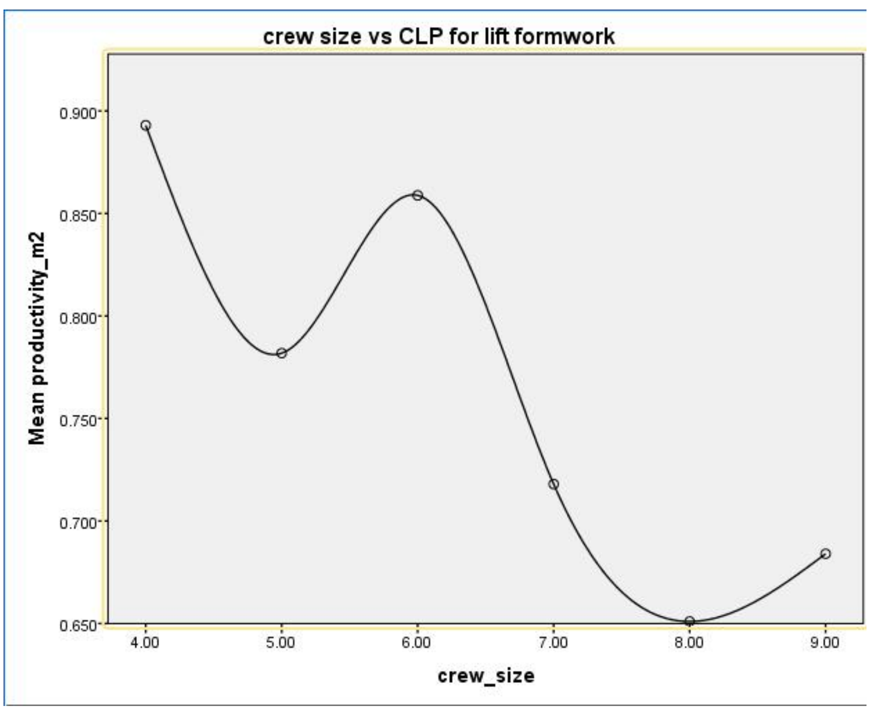

Figure 16:crew size vs CLP for lift formwork activity

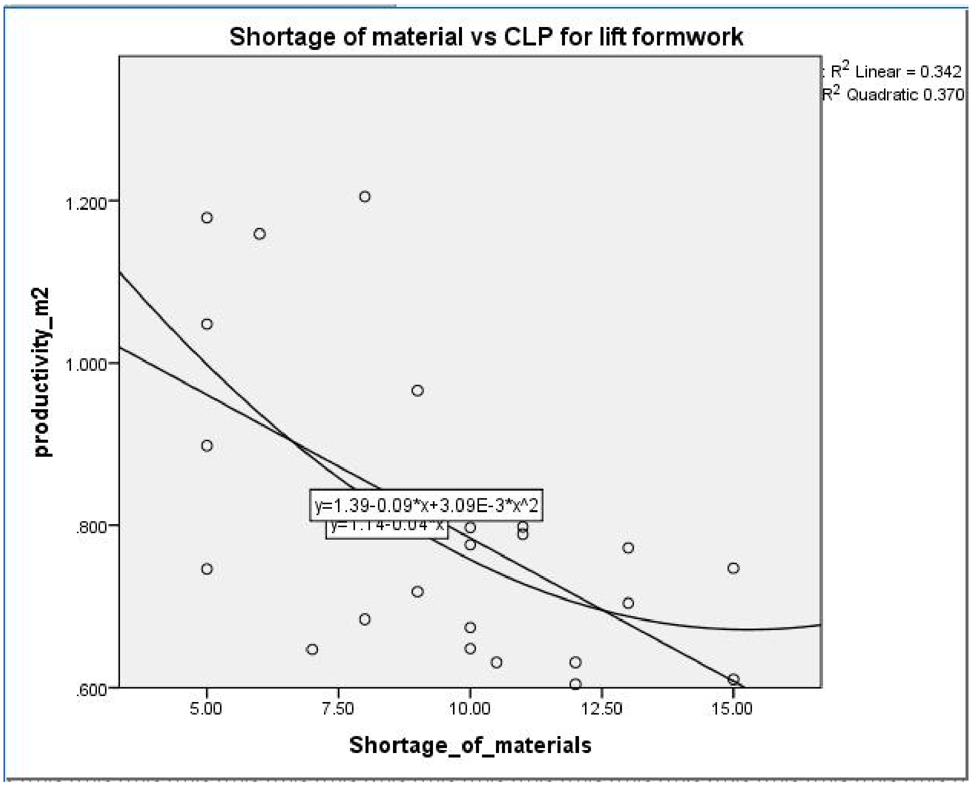

Figure 17: shortage of materials vs CLP for lift formwork activity

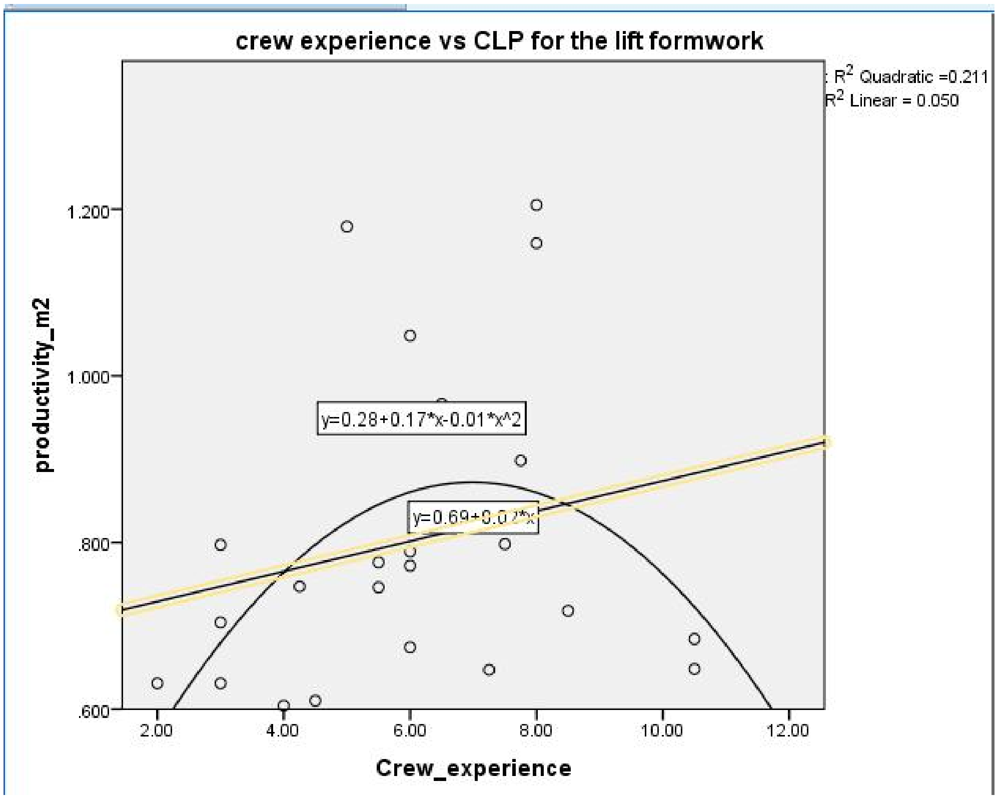

Figure 18: Crew experience vs CLP for lift formwork activity

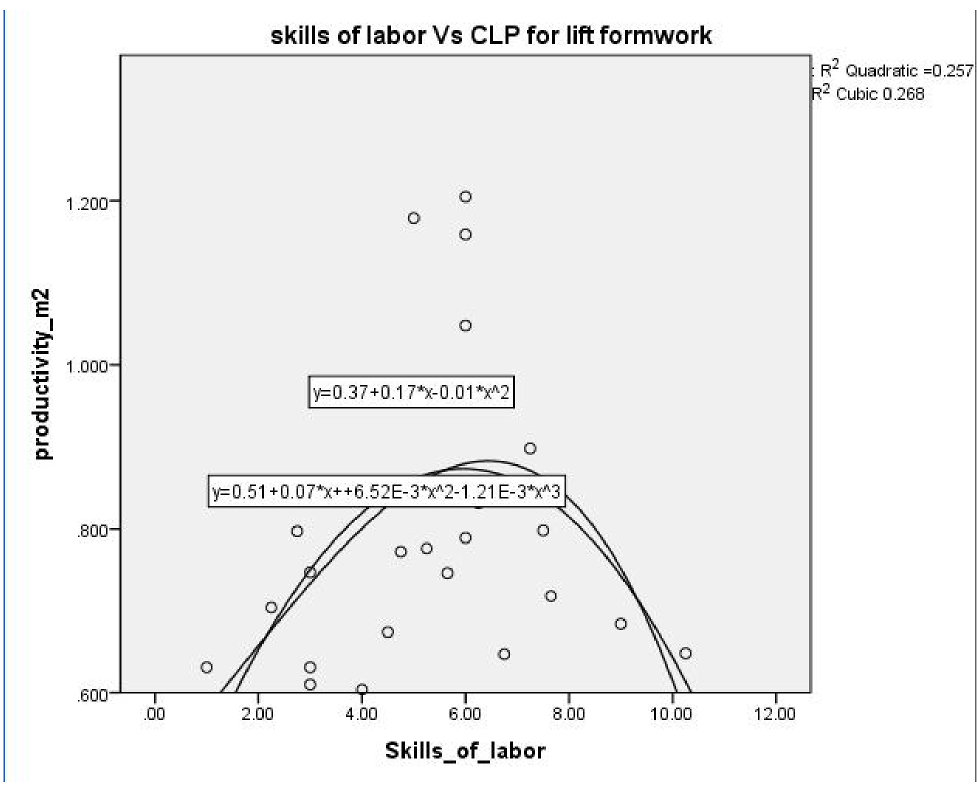

Figure 19: Skills of labor VS CLP for lift formwork

Appendix C: Pearson correlation analysis for the slab, column, lift formwork and rebaring works

Table l: The correlation analysis for the slab formwork activity

	F1	F3	F5	F8	F12	F13	F14	F16	F17	F18	F19	F20
F1	1											
F3	**-0.100**	**1**										
	0.563											
F5	**.394***	**0.106**	**1**									
	0.017	*0.537*										
F8	**.490****	**0.239**	**0.194**	**1**								
	0.002	*0.160*	*0.258*									
F12	**-0.214**	**-0.255**	**.412***	**-0.149**	**1**							
	0.211	*0.133*	*0.012*	*0.386*								
F13	**-0.181**	**-0.311**	**.341***	**-0.152**	**.887****	**1**						
	0.292	*0.065*	*0.042*	*0.377*	*0.000*							
F14	**0.267**	**0.022**	**-0.051**	**0.311**	**-.410***	**-.460****	**1**					
	0.116	*0.898*	*0.769*	*0.065*	*0.013*	*0.005*						
F16	**-0.155**	**0.038**	**-0.067**	**-0.128**	**0.090**	**0.268**	**-.349***	**1**				
	0.367	*0.826*	*0.699*	*0.458*	*0.601*	*0.114*	*0.037*					
F17	**-0.229**	**.378***	**-.341***	**0.151**	**-.527****	**-.506****	**0.180**	**0.138**	**1**			
	0.180	*0.023*	*0.042*	*0.379*	*0.001*	*0.002*	*0.293*	*0.422*				
F18	**-0.081**	**.449****	**-0.109**	**0.227**	**-0.257**	**-0.266**	**.525****	**-0.037**	**.370***	**1**		
	0.638	*0.006*	*0.528*	*0.182*	*0.130*	*0.117*	*0.001*	*0.830*	*0.026*			
F19	**0.036**	**0.156**	**0.221**	**-0.006**	**0.184**	**0.146**	**-0.319**	**0.035**	**-0.110**	**0.004**	**1**	
	0.835	*0.365*	*0.196*	*0.971*	*0.283*	*0.397*	*0.058*	*0.840*	*0.524*	*0.981*		
F20	**-.355***	**-0.139**	**-.438****	**-.467****	**0.127**	**0.174**	**-.691****	**0.180**	**-0.105**	**-.470****	**0.136**	**1**
	0.034	*0.418*	*0.007*	*0.004*	*0.459*	*0.311*	*0.000*	*0.294*	*0.540*	*0.004*	*0.431*	

The values in italic indicate the significant value.

Correlation is significant at the 0.05 level (2-tailed).*

Correlation is significant at the 0.01 level (2-tailed). **

Table m: Correlation analysis for column formwork activity

	F1	F3	F5	F8	F12	F13	F14	F16	F17	F18	F19	F20
F1	1											
F3	-0.062	1										
	0.602											
F5	0.142	0.009	1									
	0.234	*0.941*										
F8	.358**	-0.209	-0.129	1								
	0.002	*0.078*	*0.280*									
F12	0.119	-0.191	.255*	0.116	1							
	0.321	*0.108*	*0.031*	*0.334*								
F13	0.076	-0.114	.238*	-0.041	.843**	1						
	0.523	*0.338*	*0.044*	*0.730*	*0.000*							
F14	.237*	-0.070	-.311**	0.077	-0.139	-0.143	1					
	0.045	*0.559*	*0.008*	*0.521*	*0.246*	*0.232*						
F16	-.390**	-0.058	-0.117	-.249*	-0.057	0.042	-0.209	1				
	0.001	*0.631*	*0.327*	*0.035*	*0.636*	*0.726*	*0.078*					
F17	.248*	-0.019	-0.072	-0.029	-0.172	-0.179	.439**	-.256*	1			
	0.035	*0.871*	*0.549*	*0.811*	*0.149*	*0.132*	*0.000*	*0.030*				
F18	0.098	0.042	-.368**	0.089	-.298*	-.307**	.461**	-0.174	.325**	1		
	0.415	*0.725*	*0.001*	*0.457*	*0.011*	*0.009*	*0.000*	*0.143*	*0.005*			
F19	-0.225	-0.116	-.293*	-0.021	-.291*	-0.097	0.066	0.115	0.037	0.142	1	
	0.057	*0.331*	*0.012*	*0.861*	*0.013*	*0.420*	*0.582*	*0.335*	*0.755*	*0.235*		
F20	-.391**	0.063	-0.228	-0.049	0.197	0.083	-0.062	.308**	-.397**	-0.080	-0.180	1
	0.001	*0.598*	*0.054*	*0.682*	*0.098*	*0.488*	*0.606*	*0.008*	*0.001*	*0.503*	*0.130*	

The values in italic indicate the significant value.

Correlation is significant at the 0.05 level (2-tailed).*

Correlation is significant at the 0.01 level (2-tailed). **

Table n: Correlation analysis for rebaring works activity

	F1	F3	F5	F8	F12	F13	F14	F16	F17	F18	F19	F20
F1	1											
F3	**-0.310**	**1**										
	0.140											
F5	**-.523****	**.528****	**1**									
	0.009	*0.008*										
F8	**-0.144**	**-0.111**	**0.000**	**1**								
	0.502	*0.607*	*1.000*									
F12	**-0.377**	**.460***	**0.105**	**-0.082**	**1**							
	0.069	*0.024*	*0.624*	*0.702*								
F13	**-0.299**	**.454***	**0.010**	**-0.053**	**.958****	**1**						
	0.156	*0.026*	*0.963*	*0.806*	*0.000*							
F14	**-0.231**	**0.385**	**0.337**	**0.100**	**0.073**	**0.043**	**1**					
	0.277	*0.063*	*0.108*	*0.643*	*0.735*	*0.841*						
F16	**0.153**	**0.081**	**-.507***	**-0.099**	**0.093**	**0.205**	**-0.303**	**1**				
	0.476	*0.707*	*0.012*	*0.645*	*0.666*	*0.337*	*0.151*					
F17	**0.040**	**-0.261**	**0.100**	**.448***	**-0.206**	**-0.184**	**0.311**	**-0.158**	**1**			
	0.851	*0.218*	*0.643*	*0.028*	*0.333*	*0.390*	*0.139*	*0.460*				
F18	**0.335**	**-0.171**	**0.098**	**-0.035**	**-0.345**	**-0.368**	**-0.072**	**-0.061**	**0.046**	**1**		
	0.110	*0.424*	*0.648*	*0.872*	*0.099*	*0.077*	*0.737*	*0.776*	*0.829*			
F19	**-0.103**	**-0.237**	**0.016**	**0.238**	**-0.344**	**-0.286**	**.408***	**-0.067**	**0.392**	**-0.306**	**1**	
	0.632	*0.266*	*0.940*	*0.262*	*0.099*	*0.176*	*0.048*	*0.754*	*0.058*	*0.146*		
F20	**-0.329**	**0.234**	**-0.051**	**-0.050**	**.776****	**.718****	**0.017**	**0.328**	**-0.261**	**-0.124**	**-0.225**	**1**
	0.116	*0.271*	*0.812*	*0.815*	*0.000*	*0.000*	*0.936*	*0.117*	*0.218*	*0.565*	*0.291*	

The values in italic indicate the significant value.

Correlation is significant at the 0.05 level (2-tailed).*

Correlation is significant at the 0.01 level (2-tailed). **

Table o: correlation analysis for lift formwork activity

	F1	F3	F5	F8	F12	F13	F14	F16	F17	F18	F19	F20
F1	1											
F3	**-0.257**	1										
	0.226											
F5	**-.474***	**.531****	1									
	0.019	*0.008*										
F8	**.696****	**0.075**	**-0.148**	1								
	0.000	*0.728*	*0.489*									
F12	**-0.210**	**0.073**	**0.315**	**-.480***	1							
	0.325	*0.734*	*0.133*	*0.018*								
F13	**-0.179**	**0.046**	**0.351**	**-.424***	**.950****	1						
	0.401	*0.832*	*0.093*	*0.039*	*0.000*							
F14	**.502***	**0.263**	**0.033**	**.696****	**-0.336**	**-0.285**	1					
	0.012	*0.214*	*0.880*	*0.000*	*0.109*	*0.178*						
F16	**-.502***	**0.050**	**0.211**	**-.534****	**.415***	**0.385**	**-.513***	1				
	0.012	*0.817*	*0.322*	*0.007*	*0.044*	*0.064*	*0.010*					
F17	**.620****	**-0.335**	**-0.400**	**.507***	**-.523****	**-.428***	**0.383**	**-.688****	1			
	0.001	*0.110*	*0.053*	*0.012*	*0.009*	*0.037*	*0.065*	*0.000*				
F18	**.482***	**0.205**	**-0.261**	**.582****	**-.457***	**-.459***	**0.283**	**-.480***	**0.360**	1		
	0.017	*0.337*	*0.218*	*0.003*	*0.025*	*0.024*	*0.181*	*0.018*	*0.084*			
F19	**-0.253**	**0.352**	**0.219**	**-0.104**	**0.163**	**0.129**	**-0.082**	**-0.129**	**-0.144**	**-0.070**	1	
	0.233	*0.091*	*0.303*	*0.630*	*0.447*	*0.548*	*0.703*	*0.549*	*0.502*	*0.745*		
F20	**-0.283**	**-0.129**	**-0.367**	**-.585****	**0.158**	**0.224**	**-.475***	**0.254**	**-0.189**	**-0.186**	**0.093**	1
	0.180	*0.548*	*0.078*	*0.003*	*0.462*	*0.293*	*0.019*	*0.232*	*0.375*	*0.385*	*0.665*	

The values in italic indicate the significant value.

Correlation is significant at the 0.05 level (2-tailed).*

Correlation is significant at the 0.01 level (2-tailed). **