

Enhancing Labour Productivity within Construction Industry through Analytical Hierarchy Process, the Case of Gaza Strip

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Abstract Construction sector plays a leading role in economic growth for countries all around the world. Since construction is a labour intensive industry, productivity is considered a primary driving force for economic development. In the Gaza Strip, the economy is severely challenged by the combined effects of rapid population growth and the closure policy imposed on the area since 2007. Owing to this situation, construction projects are characterized by low profit margin, time and cost overrun making labour productivity a key component of company's success and competitiveness. Although, labour productivity has been subject of study by many researchers, a deeper understanding is still required to improve labour productivity. The main aim of this study is to identify key factors affecting labour productivity in the Gaza Strip. It also aims at formulating a labour productivity baseline model using the Analytical Hierarchy Process (AHP). By reviewing the literature and conducting depth interviews with experienced engineers, thirty critical factors related to labour productivity were identified and categorized into six groups: psychological, experience, supervision and leadership, physical, time and workload, and external factors. Based on the Analytical Hierarchy Process approach, a questionnaire was designed and delivered to sixty contractors to elicit the view on how labour productivity might be affected. A total of 56 feedbacks were analyzed through the AHP. The results indicated that Job satisfaction & security, lack of incentive scheme, skill & experience, drug use, overtime and weather changes have a significant impact on labour productivity in GS. In addition, the developed AHP model provides a framework that can assist managers in evaluating multiple factors and hence effectively improve labour productivity.

Keywords Analytical Hierarchy Process, Gaza Strip, Labour, Productivity, Introduction

1. Introduction

The construction sector plays a key role in boosting the economy, largely through the lens of generating the potential for employment. In this respect, the construction industry utilizes various types of resources that include; labour, equipment and materials. Particularly, in Palestine, Labour accounts for 30-50 percent of the project's cost [1]. Such a statement would point to scoring effective planning and how to manage individuals in a team. These are not only necessary to deliver a successful project but also to realizing a healthy profit.

The construction sector is one of the main driving forces to mobilizing economic growth. The statistics illustrates that the share of the labour force in the Palestinian construction industry increased from 13.2% to 15.6% for the years 2010-2013 [2]. Associated to labour, labour productivity is an issue of major concern in the Gaza Strip (GS). This is due to common phenomenon of project's time delays and cost overrun tied to poor labour productivity [3]. Hence, improving labour productivity is vital to successful project management.

Fluctuation in labour productivity is caused by many qualitative and quantitative factors. Identifying these factors and quantifying the extent to which each might have an impact on labour productivity is important to better manage labour. Although, various aspects related to labour productivity within the GS construction industry have been documented, it remains to explicitly identify a clear set of factors affecting labour productivity taking into consideration the interrelated relationship among them. With particular focus on GS, the construction sector in this area is confronted with many challenges, but one of critical impact is labour productivity. The aim of this research is, first, to identify significant factors influencing labour productivity in the GS from contractors' viewpoint and, second, to initiate the basis for labour productivity model using the Analytical Hierarchy Process.

2. A Literature Review

The literature is rich in providing several contributions related to construction labour productivity within the construction industry. Categories in previous studies can be classified into either identification factors associated with labour productivity or developing the methods and techniques necessary for estimating labour productivity [4]. In doing so, a first step is to understand and evaluate how different factors influence labour productivity. This step is a preliminary step as it assists project managers in outlining the deficiencies and therefore establishing an overall optimization strategy. A significant body of research emerges which despite differences in many countries addresses different parameters affecting labour productivity [5]. For example, [6] suggest factors that affect labour productivity in Turkey from the perspective of consultants, contractors and subcontractors. Lack of local experienced labour, schedule pressure caused by the Government and working overtime have been, amongst others, the most distinguished parameters. Differently, but related, [7] have explored the de-motivating factors in Hong Kong within labour employed in civil engineering works and followed by suggesting the consequences on labour productivity. This study reveals that extensive reworks, overcrowded work areas, problems occurred in crew interfacing, availability of tools, delays in inspection, availability of materials and incompetence of site foremen have caused 5.1–13.6 lost in man-hours per week. Furthermore, [8] go further and identify ten main factors that negatively affect labour productivity within building projects constructed in Palestinian. These include materials shortages, a lack of labour experience and surveillance, in addition to drawings and altering specification occurred during execution and payment delays. Similarly, [9] classifies the key groups influencing labour productivity using a survey of the construction companies registered in Indonesia. These groups are supervision, material, execution plan and design. Another study has been conducted on Uganda construction industry [10]. Its findings indicates that incompetent supervision, lack of skills, rework, lack/breakdown of tools, poor construction methods, poor communications, inaccurate drawings, stoppages due to rejected work, political insecurity and weather conditions largely influence labour productivity. Collectively, it can be argued that there is a lack of universal set of factors affecting labour productivity due to varying country conditions. A second step is estimating the construction labour productivity in an effort to both improve labour productivity prediction and monitoring on-site performance. In this aspect, several models have been developed in the literature which their basis departs from the relationship between various factors. For example, methods such as regression analysis [11], Artificial Neural Network [12], and Fuzzy Set Theory [13], have been reported in several studies accounting for various factors affecting labour productivity. The two steps discussed above suggest a framework in this study which is adopted in the section that follows to examine the overlap

occurred within different factors, thereby arriving at basis for a labour productivity model.

3. Analytical Hierarchy Process

The Analytical Hierarchy Process (AHP) developed by Dr. Thomas Saaty in the 1980s, is a multi-criteria decision making tool [14]. It assists in structuring complex problems into a system by capturing both qualitative and quantitative factors. The first step of the AHP consists of building a hierarchy of elements describing the problem under consideration. The objective or goal from the decision-makers viewpoint is represented at the top level of the hierarchy. This is followed by the intermediate levels that demonstrate the criteria and sub-criteria contributing to the decision. Once the hierarchies have been established, the next step is finding out the weight of each criterion with respect to others within the same level. This is accomplished via pair wise comparisons using a nine-point scale (shown in Table (1)). Pair-wise weighting among n elements in each level leads to an approximation $a_{ij} = w_i / w_j$ which is the ratio of the weight of element i to element j . The estimated weight vector w is found by solving the following eigenvector problem:

$$Aw = \lambda_{\max} w$$

where,

λ_{\max} is the principal eigen-value of A ,

and

$$A = \begin{bmatrix} w_1 / w_1 & \dots & w_1 / w_2 & \dots & w_1 / w_n \\ \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots \\ w_n / w_1 & \dots & w_n / w_2 & \dots & w_n / w_n \end{bmatrix}$$

Table 1. Pair-wise comparison scale for AHP

Definition	Importance
Equal importance	1
Weak importance of one over another	3
Strong importance	5
Very strong	7
Absolute importance	9
Intermediate values	2,4,6,8

The AHP has a unique feature in that it measures the reliability of the input data by means of a Consistency Index (CI), which enables decision-makers to determine judgments that need reassessment. The CI is a function of the maximum eigen-value (λ_{\max}) and the size of the square matrix (n). Saaty identified CI as:

$$CI = \frac{(\lambda_{\max} - n)}{(n - 1)}$$

If the decision maker is completely consistent λ_{\max} should be equal to n (CI = zero). In the case of inconsistency, λ_{\max} will be greater than n . The more inconsistent the

decision maker is, the greater the value of λ_{max} .

The AHP has been applied to a variety of areas since its development. The benefits of this approach in managing complex decisions has been discussed extensively in literature [15,16,17,18,19,20,21,22 and 23].

4. Methodology

Thirty main factors affecting labour productivity were identified through an intensive literature and consultation of eight local contractors. Initially, a review of professional journals, publications, text books and previous research papers was conducted. A powerful Scopus search engine was selected to identify journals that have published articles related to construction labour productivity. The search was carried out under the “title/abstract/ keyword” field using ‘labour productivity’, ‘workforce productivity’, ‘construction productivity and labour improvement’. Then, eight local contractors with an experience of more than 10 years in the GS construction industry were consulted to give relatively accurate judgment on different factors affecting labour productivity. These factors were grouped into six categories: psychological, experience, supervision and leadership, physical, time & workload and finally external factors. Primary data for this study were collected through a questionnaire survey developed using the Analytical Hierarchy Process. The target population of the survey includes contractors holding a valid registration from the contractors union within the Gaza Strip; where the total number found to be 72 companies. The respondents were selected based on random sampling and a representative population size of sixty contracting companies was derived from the following formulas [24]:

$$m = \frac{Z^2 \times p^* \times (1 - p^*)}{\epsilon^2} \text{ and}$$

$$n = \frac{m}{1 + (\frac{m-1}{N})}$$

Where: n, m and N are sample size for limited, unlimited available population.

Z: value (1.96 for 95% confidence level), ϵ : maximum error of the point estimate

P*: degree of variance between the elements of population (0.5)

$$m = \frac{(1.96)^2 \times 0.5 \times (1 - 0.5)}{(0.05)^2} = 384.16 = 385 \text{ and}$$

$$n = \frac{385}{1 + (\frac{385-1}{72})} = 60$$

5. Results & Discussion

A hierarchical model for factors affecting labour productivity was developed consisting of three levels: the goal, the critical factors and sub-factors. This model was used as a basis for designing the questionnaire survey where relative importance of each factor in the hierarchy is determined (Figure 2). Experts have been asked to make pair-wise comparisons between two factors at a time, decide which factor is more important to labour productivity, and then specify the degree of importance on a scale between 1 (equal importance) and 9 (absolutely more important) to the more important factor. A total of 56 questionnaires were completed by contractors and engineers, representing a response rate 93.3 percent. The main characteristics of the populations being sampled were experts’ contractors with more than 14 years of experience in the GS construction industry having a direct and daily interaction with labour; as 50% of participants held a site engineer position. Therefore, the responses considered to be a good representation of the target survey population.

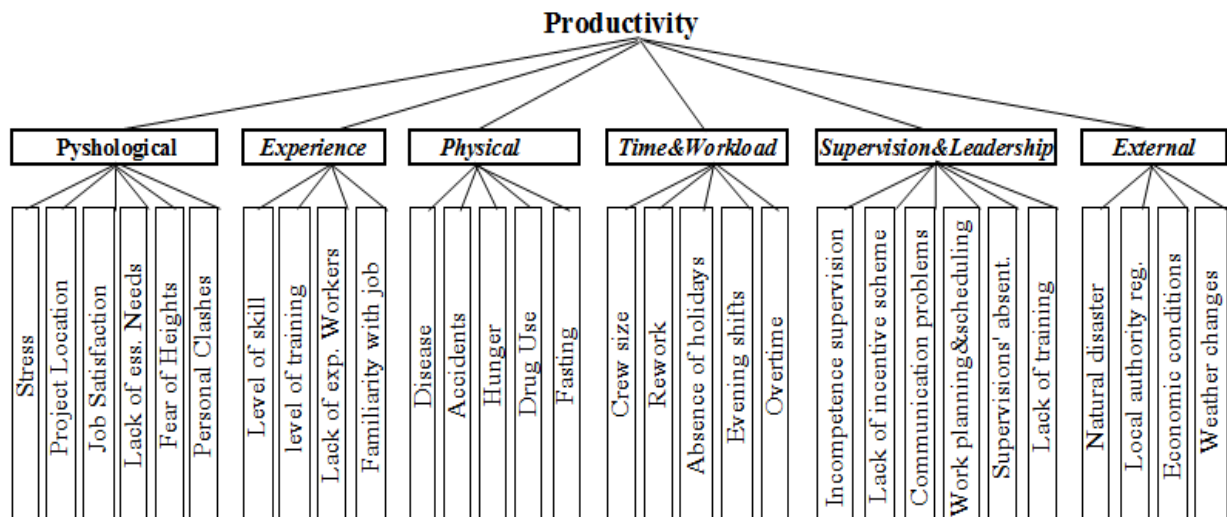


Figure 1. The Analytical Hierarchy Process Productivity Model

The geometric mean approach was then used to combine the individual judgments to resolve the lack of consensus on values. The geometric means of the judgments obtained for each group of factors are presented as the weight in Tables (2).

Table 2. The Geometric means of different groups of factors

Psychological Factors			Weight
Job satisfaction & security	More important than	stress	8
Job satisfaction & security	More important than	Personal clashes	7
Job satisfaction & security	More important than	Workers fear of heights	8
Job satisfaction & security	More important than	Project location	3
Job satisfaction & security	More important than	Lack of essential needs	3
Lack of essential needs	More important than	Personal clashes	6
Lack of essential needs	More important than	Workers fear of heights	7
Lack of essential needs	Equally important to	Project location	1
Lack of essential needs	More important than	Stress	7
Project location	More important than	Workers fear of heights	9
Project location	More important than	Workers fear of heights	5
Project location	More important than	Workers fear of heights	9
Stress	Equally important to	Workers fear of heights	1
Stress	More important than	Personal clashes	3
Workers fear of heights	Equally important to	Personal clashes	1
Experience Factors			Weight
Skill & experience level	More important than	Familiarity with job	4
Skill & experience level	More important than	Level of training	7
Skill & experience level	More important than	Lack of experienced labour	5
Skill & experience level	More important than	Familiarity with job	4
Skill & experience level	More important than	Level of training	7
Skill & experience level	More important than	Lack of experienced labour	5
Familiarity with job	More important than	Level of training	3
Familiarity with job	More important than	Lack of experienced labour	3
Level of training	Equally important to	Lack of experienced labour	1
Physical Factors			Weight
Accidents	More important than	Disease	3
Disease	More important than	Hunger	3
Drug use	More important than	Disease	5
Disease	More important than	Fasting	3
Accidents	More important than	Hunger	5
Accidents	More important than	Fasting	6
Drug use	More important than	Accident	5
Drug use	More important than	Hunger	7
Drug use	Equally important to	Fasting	1
Drug use	More important than	Fasting	8
Time & Workload Factors			Weight
Crew size	Equally important to	Rework	1
Abs. of holidays	More important than	Crew size	5
Evening shifts	Equally important to	Crew size	1
Overtime	More important than	Crew size	8
Abs. of holidays	More important than	Rework	3
Rework	More important than	Evening shifts	3
Overtime	More important than	Rework	5
Abs. of holidays	More important than	Evening shifts	4
Overtime	More important than	Abs. of holidays	3
Overtime	More important than	Evening shifts	7
External Factors			Weight
Local authority reg.	More important than	Natural disaster	2
Economic conditions	More important than	Natural disaster	4
Weather changes	More important than	Natural disaster	7
Economic conditions	More important than	Local authority reg.	3
Weather changes	More important than	Local authority reg.	4
Weather changes	More important than	Economic conditions	5

After determining weights, the analysis was carried out with the application of the AHP using the ‘Criterium Decision Plus’ support software. The importance of each factor with respect to classified group was first developed (Tables 3-8). Then, an overall assessment was carried out. The consistency of responses is considered satisfactory; as the value of Consistency Ratio (CR) is less than 0.1 across different groups of factors.

Table 3. ‘Psychological’ factors weights

Criterion	Weight
Stress	0.046
Project location	0.237
Job satisfaction & security	0.425
Lack of essential needs	0.219
Workers fear of heights	0.039
Personal clashes	0.033
Consistency Ratio	0.061 < 0.1

Table 4. ‘Sup. & leadership’ factors weights

Criterion	Weight
Incompetence supervision	0.137
Lack of incentive scheme	0.344
Communication problems	0.047
Work planning & scheduling	0.265
Supervision absenteeism	0.163
Lack of training sessions	0.044
Consistency Ratio	0.058 < 0.1

Table 5. ‘Physical’ factors weights

Criterion	Weight
Disease	0.111
Accidents	0.228
Hunger	0.049
Drug use	0.566
Fasting	0.046
Consistency Ratio	0.057 < 0.1

Table 6. ‘Time & Workload’ factors weights

Criterion	Weight
Crew size	0.066
Rework	0.102
Absence of holidays	0.250
Evening shifts	0.057
Overtime	0.525
Consistency Ratio	0.037 < 0.1

Table 7. ‘Experience’ factors weights

Criterion	Weight
Skill and experience	0.613
Level of training	0.081
Lack of experienced labour	0.090
Familiarity with job	0.217
Consistency Ratio	0.027 < 0.1

Table 8. ‘External’ factors weights

Criterion	Weight
Natural disaster	0.061
Local authority regulations	0.109
Weather changes	0.612
Economic conditions	0.218
Consistency Ratio	0.072 < 0.1

Based on findings presented in Table (3), ‘job satisfaction & security’ is a dominant factor within the psychological group. It indicates a direct correlation between job satisfaction and productivity. Generally, a satisfied labour has a positive attitude towards job and high work commitment; tends to attend on time, work speedily with less absenteeism. In the GS context, due to the current political situation and imposed closure on the area, high unemployment rates exist. In effect, contractors depend to great extent on temporary contracts. These contracts are characterized by low average wage and long working hours, causing job dissatisfaction and insecurity within construction labour. Effect of ‘job satisfaction & security’ was further recognized among the important factors affecting construction labour productivity in other countries such as Turkey [25], and UAE [26]. Meanwhile, the results of prioritization of the factors related to ‘supervision & leadership’ demonstrated that ‘lack of incentive scheme’ and ‘work planning & scheduling’ are ranked as first and second with a weight of 0.344 and 0.265 respectively (Table 4). [8] Supported this result; highlighting the fact that financial benefits play a vital role in motivating labour force to achieve the predetermined goals. In addition, similar results were obtained by [1] while discussing the influence of ‘work planning & scheduling’ on labour productivity. Furthermore, findings indicated that ‘drug use’ and ‘accidents’ are the most important factors within the physical group (Table 5). Clearly, both factors contribute to on-site productivity loss; as drug use causes physical harms, while the effect of ‘accidents’ will vary depending on the accident type. With regard to GS construction industry, the scale of the drug problem is of a concern to labour productivity especially with the current lack of treatment and rehabilitation centres in the area. Findings also show that overtime with a weight of 0.525 has the highest rank within the ‘time & workload’ group (Table 6). Although, allowances attached to overtime will motivate labour and enhance productivity, working overtime on continuous basis create an adverse effect on physical strength of labour and thus lead to productivity loss. This result is justified; because of the nature of the GS construction industry, as it is mostly involve working overtime due to shortage in skilled labours as well as schedule pressure. It also aligns with those of [27] and [6], who found that overtime has a significant impact on on-site labour productivity. In similar way, absence of holidays can cause work fatigue and hence the ability of workers to concentrate on work will decrease leading to decline in productivity rate.

‘Skill & experience’ and ‘familiarity with job’ are considered the most significant factors affecting labour productivity among the experience group (Table 7). Both factors were documented in literature [10 and 6] as constraints in attaining a full performance potential. This result reflects the skilled labour gap in the GS construction industry despite relatively high levels of unemployment. Also, based on the results of the external factor group (Table 8), weather changes obtained the highest weight, followed by economic conditions. Performing work in hot or cold weather can impact labour visibility, safety as well as comfort leading to productivity loss. With GS located on the Mediterranean Sea, the weather can be classified as hot and humid in the summer, meanwhile, rainy during the winter. In addition, economic conditions governed by unstable political situation, national inflation rates and construction employment can be classified as a main driver to productivity loss in GS construction industry.

Finally, an overall assessment for the main groups with respect to productivity was then carried out to establish the AHP model (Fig. 2). It can be seen that physical and experience groups have the most significant role in labour

productivity (Table 9).

Table 9. ‘Productivity’ groups weights

Criterion	Weight
‘Psychological’ factors	0.087
‘Experience’ factors	0.261
‘Physical’ factors	0.304
‘Time & workload factors	0.174
‘Supervision & leadership factors	0.130
‘External’ factors	0.043

The model shown in Figure (2) pinpointed thirty factors related to construction labour productivity and mapped out their relationships in an AHP hierarchy. Deriving the priorities of these factors in the form of pair-wise comparisons yields reliable results, where the reliability of the pair-wise subjective judgments was verified using the consistency check. This model can be used as a reference for determination of areas to increase the value of construction productivity, by better planning and eliminating the impact on labour productivity.

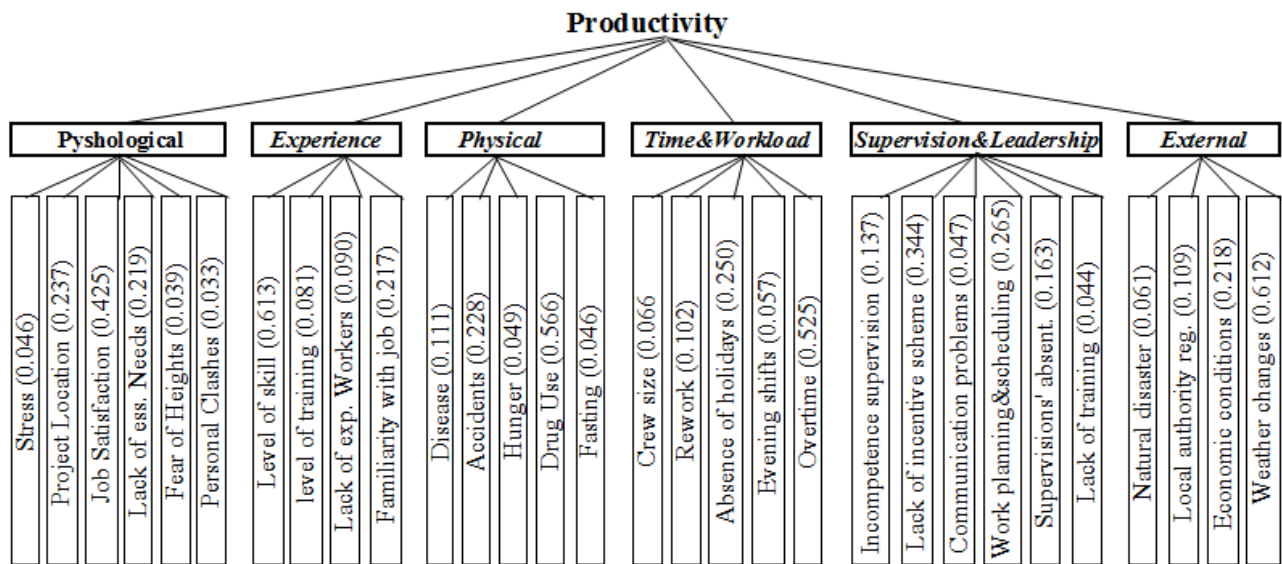


Figure 2. The Analytical Hierarchy Process Productivity Model

6. Conclusions

This study aimed at identifying factors influencing labour productivity in the Gaza Strip construction industry. Furthermore, it aimed at establishing the foundation of further study of labour productivity improvement by establishing a baseline model. In formulating this model, thirty factors closely associated with labour productivity were considered using the Analytical Hierarchy Process.

The Analytical Hierarchy Process has proven to be useful in quantitatively analyzing the interrelation between various factors. Results from different sub-groups demonstrated that Job satisfaction & security, lack of incentive scheme, skill & experience, drug use, overtime and weather changes have a significant impact on labour productivity. Meanwhile, with regard to main groups, *physical factors* group contributed the most to the onsite labour productivity.

This work provide a clear indication of the effectiveness of the established AHP model to offer construction companies in Gaza Strip an insight to critical areas for labour productivity improvement, thereby saving time and money. In addition, the AHP model is easy to apply and it also offers the flexibility to add more factors and continually refine the group's preferences among concerned criteria and sub-criteria.

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