A model for construction performance improvement stimulation for a developing economy

This item was submitted to Loughborough University's Institutional Repository by the/an author.


Metadata Record: https://dspace.lboro.ac.uk/2134/23927

Version: Published

Publisher: Nanyang Technological University

Rights: This work is made available according to the conditions of the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0) licence. Full details of this licence are available at: https://creativecommons.org/licenses/by-nc-nd/4.0/

Please cite the published version.
A MODEL FOR CONSTRUCTION PERFORMANCE IMPROVEMENT
STIMULATION FOR A DEVELOPING ECONOMY

N. M. Lema, A. D. F. Price
Department of Civil and Building Engineering, Loughborough University of Technology,
Leicestershire LE11 3TU UK.

R. S. Minga,
Department of Civil Engineering, University of Dar es Salaam, Box 35131, Dar es Salaam
Tanzania.

ABSTRACT
This paper describes work initiated by the government in Tanzania aimed at benchmarking
labour productivity amongst building contractors, and to thereby establish a construction
labour productivity performance related database and stimulate competitive performance. A
clear need for performance improvement for construction industries in African developing
countries is set out. Labour productivity has been identified as a critical factor in performance
improvement and arguments have been put forward to justify the concentration of efforts to
improve labour productivity at site level. Productivity benchmarks were established by
observing site output using the activity sampling technique. The proposed benchmark is an
asymptotic upper productivity figure which can be used for establishing a continuous
productivity improvement programme. The project concepts used are then compared with
Total Quality Management (TQM) and benchmarking concepts.

INTRODUCTION
This paper describes a study initiated by the government in Tanzania aimed at benchmarking
labour productivity amongst building contractors. This work should result in the
establishment a construction labour productivity performance related database and help to
stimulate competitive performance. Labour productivity was identified as a critical factor in
performance improvement. This paper concentrates on the process of establishing labour
productivity benchmarks based on site output observations using activity sampling. A total of
over 8000 manhours have been spent observing labour output on construction sites at various
centres throughout the country between 1984 and 1993. The benchmarks were used to
generate minimum labour cost inputs into unit rates - referred to as base rates - which will
form the basis for competitive pricing and tendering and thereafter tender evaluation and
project cost control.

The significance of timely and accurate information for decision making has been identified by
various researchers (Guevara & Boyer, 1981; Tenah, 1986; Radsorf & Herbert, 1990). Most
African developing economies lack systematic long-term information upon which to base
business and development decisions. The construction industry is particularly prone to this
problem due to its fragmented nature, not only in developing countries but also in developed
countries. The unavailability of information on the construction labour and plant output is a
common phenomenon even in Britain (Price, 1986). A study based in Nigeria in mid-eighties
established that output levels of building operatives were generally unavailable and six out of
seven firms surveyed base their output for estimating and planning purposes on 'experience'
(Olomolaiye & Ogunlana, 1989). A similar study in Tanzania at about the same time also
concluded that most construction companies did not have operative output data, and where
these existed they were unreliable (Parker et al. 1987). Wells (1986) had earlier noted that
most local contractors in developing countries only knew at the end of the project if they had
made a profit or a loss, and some were likely not to know anything at all due to the poor
nature of information management. Construction industries in developing African countries
therefore find themselves in a vicious circle of lack of reliable information leading to poor
performance which in turn leads to poor or no information.

In such an environment, it is not enough to identify average outputs as these generally
represent poor performance. Methodologies have then to be devised to enable the industry to identify, isolate and adopt practices that lead to better performance. The process of identification and adoption of best practices that leads to better performance is now known as benchmarking (Camp, 1989). The benchmarking practice was pioneered by the Japanese manufacturing industries and is now widely used by leading companies in United States of America as a method of attaining world class performance (Watson, 1993). It is envisaged that the Schedule of Rates project will proceed further into benchmarking site, project management and industry wide practices for continuous performance improvement.

THE NEED FOR PERFORMANCE IMPROVEMENT

Construction industry performance in African developing countries

The construction industry plays a dynamic role in the process of economic growth and development as it forms a major capital goods industry. The industry typically consumes 50-70 per cent of the public investment, contributes 5-10 per cent of the Gross National Product (GNP), and is probably the largest single employer outside agriculture in developing countries (Wells, 1986). Turin (1972) and Wells (1986) demonstrated that there is a close relationship between construction activity and economic growth. Consequently, the construction industry's performance has a significant effect on the performance of the economy as a whole. Improvement of the construction industry performance is an issue of wide concern even in developed countries. The Business Roundtable 1993 in Britain reported that construction productivity could be improved as much as between 50-60 per cent and that some organisations are actually aiming at 100 per cent improvement (Priestley, 1994). The Latham report on the review of the construction industry in Britain recommended a 30 per cent real cost reduction based on productivity improvement by the year 2000 (Latham, 1994). These serve to highlight the productivity improvement gap in developing countries.

The framework for evaluation of the construction industry performance is not universally agreed, nor should it be since emphasis and priorities differ. Wells (1986) suggested a number of indicators against which the performance of the construction sector in any country could be evaluated. These included:

- the extent to which the construction projects are completed on time;
- the percentage of imports in the total construction output;
- the degree of development of local skills and local participation in contracting;
- the extent of development in the local building materials industries; and
- the overall efficiency/productivity of the construction sector and the extent to which construction plans are implemented within cost limits.

Ofori (1994) suggested a more specific set of indicators under a different setting. Wells (1986) concluded that given above indicators, the vast majority of the number of developing countries, (for which information was available in 1986), fared very badly. This view is confirmed by a number of other authors including The World Bank (1983), Edmond & Miles (1984), and Miles & Neale (1991). In terms of volume of construction, sub-Saharan Africa (this excludes South Africa) contributed only about 1.2 per cent to the increase of the value added by construction in the world between 1970 and 1984, with Nigeria contributing more than half of this. When compared to United States of America, Britain and Japan whose contribution in the same period was about 15 per cent, 3 per cent and 12 per cent respectively (Pheng, 1991a; 1991b). These figures must be of some concern.

Construction performance and improvement initiatives in Tanzania

Historically, the Tanzanian construction industry suffered major setbacks soon after independence in 1961. It is recorded that there was no Tanzanian in the construction industry above the level of a general foreman at the time of independence (Wells, 1986). This was followed by an exodus of foreign companies along with its experts during the next three years.
following a slump in the construction activity. Studies performed in 1968 showed that with the exception of simple warehouses and simple repetitive construction, all other areas of the construction market were characterised by a serious lack of competition, high contract prices and excessive profits (Bienefeld, 1968).

In order to improve performance, contractor development schemes have become part of national programmes in a number of developing countries. However, most of these have achieved little because many have concentrated on the symptoms without considering the root causes (Ofori, 1991). Tanzanian public owned construction organisations were established early as initiatives to improve performance. Wells (1986) noted that these failed to perform for a variety of reasons.

A major study performed in 1977 was aimed at identifying factors contributing to the problems inherent in Tanzanian construction and recommend steps to improve the situation (Ministry of Works, Tanzania, 1977). The industry was characterised by:

- low productivity;
- unavailability of required resources, skilled manpower, materials, equipment;
- unsatisfactory capacity utilisation;
- imbalances of capacities of the different sub-sectors; and
- low competition, high contract prices and high profit rates;

As a result of this study, the National Construction Council (NCC) was established by an Act of Parliament (No. 20; 1979) to bring order to the construction industry. A priority problem identified in the study was low productivity, highlighted by the fact that the costs of construction in Tanzania were the same as those prevailing in Europe, while wages were significantly lower. In a recently performed study focusing on cost trends of both construction inputs and outputs, the ratio between cost of basic inputs and prices of the outputs was found to vary between three to five times (Lema, 1992). Furthermore, it was observed that the costs of the construction process were increasing unproportionately for the same unit cost of construction in real terms during the period 1978-90. This suggests that the delivery process was in effect becoming more and more inefficient. The quality of actual site management is still very poor, resulting in gross cost and time over-runs. The ratio of actual construction period and contract period at the time of tender is of the order of three to four, and cost over-runs are of the order of 1.5 to 2.5 times (Lema et al. 1988). The very objective of a Schedule of Rates was to address this problem. More recently, the government unveiled a policy document aimed at guiding the development of the construction industry (Ministry of Works, 1992). The improvement of labour productivity and the establishment of realistic construction costs feature strongly in this document.

THE DEVELOPMENT OF SCHEDULE OF RATES

Initiation and concept of Schedule of Rates project

In 1984, the NCC engaged the Department of Civil Engineering of the University of Dar es Salaam as consultants for the Establishment of a Schedule of Rates for the building construction industry in Tanzania. The project was established specifically as a first step towards addressing the cost escalation problem. Earlier studies had suggested that the escalators were more than just material price increases or materials shortages, and that other factors embodied in management and overhead structures, as well as operative productivity, may also be contributors to the problem (Beinefeld, 1968; Ministry of Works, 1977).

The initial stage of the project was to develop an acceptable approach to the Schedule of Rates that would address the issue of construction project cost control from the point of view of a public client. Based on the notion of establishing a Schedule of Rates as proposed by consultants, it was necessary to perform extensive site labour productivity studies combined with material cost surveys. Together, they would form the basis for unit costs or rates which
The concept of a Schedule of Rates as a statistical reduction of historical tender rates was rejected in favour of the "base rate" concept, whereby rates based on materials and direct labour input, using up-to-date material prices, wage rates and labour productivity rates, are used as benchmarks against which tender rates are compared. The base rate concept was favoured for the following reasons: (Parker et al. 1987)

- it is a closer reflection of direct costs, since it is built up on the costs of direct inputs of materials and manpower;
- as a benchmark, the gap between it and the tender rates would be a reflection of the performance improvement opportunity for a contractor; and
- it is easily understood for what it is, and is easily up datable. As direct cost estimates, base rates could therefore be treated as minimum unit rates.

The underlying method statement of the base rate concept is "labour intensive", i.e. using simple tools and machines. The underlying assumption is that building works, as opposed to civil works, are basically labour intensive, and that labour intensive rates should provide the benchmarks. This should not introduce any conflict with equipment intensive methods which should be substituted when labour intensive methods become uneconomical or uncompetitive, and as such lead to lower unit costs. This paper concentrates on the labour productivity aspects of the Schedule of Rates project.

Significance of labour productivity

Labour productivity, although only a partial measure of productivity, has been widely accepted as performance measure in the construction industry (Lowe, 1987; Handa & Abdalla, 1989; Olomolaiye & Ogunlana, 1989; Emsley et al. 1990). The emphasis on labour derives from several reasons:

- labour is the most important factor and most easily quantifiable;
- it is the only factor that has conscious control over its contribution to output;
- labour is a resource which can appreciably be influenced by the quality of management; and
- labour productivity is often an issue of contention between management and employees, it is therefore important that both parties are equipped with relevant data.

Further, labour intensive based estimates require well-defined and quantitative measures of labour productivity, hence the emphasis on measurement of labour productivity on site, and on rigorous statistical analysis of the same.

Labour productivity benchmark - the concept

A benchmark, originally a land surveying terminology, is defined in the Concise Oxford Dictionary as "mark cut out in rock etc. by a surveyor to mark a point in line of levels making a criterion or point of reference". In the business world, a "benchmark" has been defined as a measure of best-in-class performance, a reference or measurement standard for comparison; a performance level recognised as the standard of excellence for a specified business process (Watson, 1993).

In the Schedule of Rates project, the determination construction labour productivity benchmarks was considered necessary. However, before the concept is defined, two
additional labour productivity definitions are necessary. These definitions should be interpreted within the observation time interval.

Overall Productivity (OP) = \frac{\text{Volume of work done}}{\text{Total number of manhour spent}}

Actual Productivity (AP) = \frac{\text{Volume of work done}}{\text{Total active manhours spent}}

or Actual Productivity (AP) = \frac{\text{Overall productivity}}{\text{Activity rating}}

In other words, actual productivity is the productivity when the unproductive time is eliminated. Within these definitions, "labour productivity benchmark" is defined as the 95th percentile of the population distribution of the actual productivities for a particular activity as illustrated in Figure 1. This is referred to as the maximum achievable productivity (MAP). The figure represents an assumed normal distribution although in specific cases some distributions may be different from normal. The benchmark in this context is to serve as an asymptotic upper labour productivity figure for which a benchmarking gap analysis can be made for individual construction companies.

\[ \text{MAP} = \mu_\sigma + 1.645\sigma_\sigma, \]

\( \mu_\sigma \) = overall productivity mean

\( \mu_\sigma \) = actual productivity mean

\( \sigma_\sigma \) = actual productivity standard deviation

\[ \text{MAP} = \text{Maximum achievable productivity} \]

Figure 1: Labour productivity benchmark concept

**SOURCES AND APPROACH TO DATA COLLECTION**

**Availability and reliability of labour productivity data**

An attempt was made at the onset of the project to collect documented labour productivity data from various government offices, construction companies and consulting firms. Most organisations could not provide any data at all. Data obtained from a few organisations were very unreliable. Some were based on a single observation, and conflicting information was often obtained from two different departments in the same organisation, e.g. the planning department would provide information which was completely different from that provided by the estimating department. This quickly led to the conclusion that detailed productivity data collection was necessary.

**Productivity data collection methodology - work sampling**

The concept of the Schedule of Rates necessitated that labour productivity data be obtained that would enable an assessment leading to the determination of minimum labour cost input into an item of work. This required simple and reliable data collection methodology, identification of work tasks on site that would lead into an accomplishment of an item and identification of sites
that would form a representative sample for the analysis. Work sampling technique was chosen for the following reasons:

- it would provide scope for the calculation of actual time spent on direct work, contributory work and ineffective work;
- observation skills required in this technique are not as demanding as those required to accomplish similar objectives using other techniques such as time study;
- it would be possible to attach statistically quantifiable inferences to the results of the study; and
- there was enough evidence of the use of this technique successfully elsewhere (Parker & Oglesby, 1972).

The study framework was such that each a time work task observation was made, the data should bear a 95 per cent confidence level that it is accurate to within +5 per cent or -5 per cent of the true proportions identified in the study as supported by experiences and literature recommendations elsewhere (Parker & Oglesby 1972; Gregerman 1981). In order to draw up conclusions on the population, the sample size should be not less than 30 random work task observations based on the assumption that a normal distribution model can be applied. Further, the actual site observations were based on a randomly generated observation interval of a minimum of one and a maximum of five minutes to avoid the possibility of a misrepresented observation of a cyclic activity by setting a fixed observation interval. About 400 observations were made in order to achieve the accuracy criteria in all activity proportions. This approach has also been recommended on the basis of other experiences (Harris & McCaffer, 1989).

Choice of study activities and scope of data collected

Concreting and blocklaying were identified as the priority activities for which activity sampling studies were first made, based on relative cost of the item in a typical building, ease with which labour productivity would be quantified and labour intensity of the activity. The paper therefore describes the labour productivity benchmark concept utilising the observation results of these activities. The two activities constitute about 600 observation manhours out of a total of about 8000 manhours spent on construction sites in various centres throughout the country performing work sampling studies within the above framework (Lema & Shirima, 1992). This was achieved by using third year BSc Engineering students of the University of Dar es Salaam during their vacation periods. Data collected involved site conditions, brief descriptions of actual activity, activities performed, gang size, basis of payment and actual payment, incentives, level of supervision and more important, the quantification of work done during the observation interval.

DATA ANALYSIS

Descriptive statistics of the data

Labour productivity data in the present analysis was collected from various sites in Dar es Salaam. Table 1 summarises the sources and the scope of data collected for the concreting and blocklaying activities.
Table 1: Sources and scope of concreting and blocklaying data

<table>
<thead>
<tr>
<th>Activity</th>
<th>Observations</th>
<th>Sites</th>
<th>Contractors</th>
<th>Work done</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Max.</td>
<td>Min.</td>
<td>Mean</td>
<td></td>
</tr>
<tr>
<td>Concreting</td>
<td>80</td>
<td>44</td>
<td>41</td>
<td>31.4m³</td>
<td>0.58m³</td>
<td>8.1m³</td>
<td></td>
</tr>
<tr>
<td>Blocklaying 230 mm wall</td>
<td>78</td>
<td>18</td>
<td>12</td>
<td>32.4m²</td>
<td>0.5m²</td>
<td>12.4m²</td>
<td></td>
</tr>
</tbody>
</table>

Labour productivity benchmarks

Using the box and whiskers plot, extreme values and outliers were identified and replaced by mean values before the calculating the productivity benchmarks. The labour productivity benchmark concept advanced above assumes that labour output is normally distributed. The 95th percentile output level is based on the normal population distribution of actual labour productivity. This is a simplified assumption which has still to be verified as part of the ongoing work. Preliminary analysis of the data does not preclude the normality assumption based on normal probability paper plots although it is clear that the productivity distribution is slightly skewed to the left. It is on this basis that the normal distribution model is used to represent the distribution of the actual productivity. The resultant mean and standard deviation are therefore used to determine the 95th percentile hence the benchmarks. Table 2 below summarises the basic productivity data statistics and the labour productivity benchmarks.

Table 2: Productivity data statistics and benchmarks

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Blocklaying (m²)</th>
<th>Concreting (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Maximum</td>
<td>1.85</td>
<td>2.65</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.03</td>
<td>0.06</td>
</tr>
<tr>
<td>Mean, ( \bar{x} )</td>
<td>0.70</td>
<td>1.03</td>
</tr>
<tr>
<td>Std. deviation, ( s )</td>
<td>0.45</td>
<td>0.59</td>
</tr>
<tr>
<td>95th percentile*</td>
<td>1.44</td>
<td>2.00</td>
</tr>
<tr>
<td>Benchmark (MAP)</td>
<td>-</td>
<td>2.00</td>
</tr>
</tbody>
</table>

* 95th percentile \( = \bar{x} + 1.645 \times s \) (based on the normal distribution assumption)

A: Overall Productivity in units/manhour;
B: Actual Productivity in units/manhour;
C: Activity Rate (in percentage)

DISCUSSION OF THE RESULTS

The labour productivity benchmarks obtained above represent ideal figures to enable individual contractors to determine their performance gap. It is to be noted that the benchmark for blocklaying is about three times the mean overall productivity and about twice the mean actual productivity. It is also interesting to note that the maximum observed overall
productivity for blocklaying was 1.85m²/manhour and this was achieved at 69.7 per cent activity rate. The benchmark of 2.00m²/manhour is therefore not unrealistic.

The 95th percentile figure of the overall productivity was rejected because it still represented a degree of labour utilisation inefficiency. This view is confirmed by the fact that even on sites where maximum overall productivities were exhibited, only average labour activity level were observed. In both blocklaying and concreting, maximum outputs observed were achieved at 69.7 and 57 per cent respectively. The maximum achievable concept therefore combines both qualities of high overall productivities and high labour utilisation levels.

The activity sampling technique has been successfully used to establish labour utilisation patterns for selected activities making it easier for contractors to address labour downtime problems. An average labour activity rate of 64 per cent was observed in the sample data analysed. The study does not however provide answers leading to establishment of optimal utilisation levels. Further work is expected to incorporate findings from other studies as regards relaxation allowances and other related issues.

Comparisons with Total Quality Management (TQM) and benchmarking

There are a few parallels to be drawn between TQM, benchmarking and the productivity improvement concept discussed in this paper. Performance gap analysis has been recognised as fundamental in embarking on a performance improvement strategy. The implementation of both TQM and benchmarking in an organisation require an initial assessment of performance gap. Both advocate performance improvement on a continuous basis. The performance improvement programme in Tanzanian construction industry labour productivity is based on the same principles. By setting a 'moving' asymptotic productivity figure as a benchmark, the industry is expected to move towards the benchmark and as improvements take place, the benchmark moves further forward on a continuous basis.

The concept of benchmarking clubs is now widely accepted with the purpose of the members pooling information and to guide and direct membership towards improving performance. In Britain, the government has set up a fund to assist trade associations set up such benchmarking clubs in the construction industry (Williams, 1994). In developing countries, governments find themselves in a more demanding role where direct participation is necessary if such efforts have to succeed in view of the low level of development and lack of competitiveness in the construction industry. Such direct measures have been found necessary since mid 1970's as a result of failures of indirect measures (Wells 1986, Ofori 1991). The pooling of productivity information through government assistance is parallel to the benchmarking clubs concept in the Western world.

CONCLUSIONS

The paper has set out a clear need for performance improvement for construction industries in African developing countries. Arguments have been put forward to justify the concentration of efforts to improve labour productivity at site level. The paper proposes the activity sampling technique as a simple labour productivity data collection technique to fill the productivity data vacuum in most African developing countries. The simplicity of the technique enables quick mobilisation and training of the observers. The paper has attempted to provide a framework for establishing labour productivity benchmarks by the use of data statistical characteristics. There is, however, a further need to determine the actual statistical distributions so as to refine the concept. The proposed benchmark is an asymptotic upper productivity figure which can be used for setting a up a continuous productivity improvement programme. The contractor involvement can be seen as an initial step towards building not only an in-house capability, but one that can be used in the benchmarking club context. While the project concentrated on setting productivity benchmarks, it is envisaged that a study of site factors and best practices will enable full benchmarking studies amongst contractors.
REFERENCES


Ministry of Works, Tanzania, (1977). Local construction industry study, Ministry of Works, Dar es Salaam, Tanzania


