Labour Productivity Benchmarking In Greek Projects

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Research paper

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New management thinking like that of lean construction has suggested principles and techniques that can result in better project performance. This paper aims to demonstrate the conceptual benchmarking principles for construction labour productivity and implement these in some projects in Greece, by the use of indices and measures of benchmarking in labour productivity. Indices such as the disruption index (DI), performance ratio (PR), project management index (PMI), and project waste index (PWI) are calculated. From the application of the above indices it was concluded that the benchmarks of labour productivity was found to be an important delineator between good and poorly performing projects.

Keywords
labour productivity, benchmarking, performance, construction

INTRODUCTION

The need for better productivity measurement, materials and equipment utilization arises from the relatively new concept of sustainable development especially in areas in Greece such as West Macedonia. If this is the case performance monitoring seeing as an adaptive approach to more closely link sustainability with project productivity is a crucial factor. Performance measurement is the activity of checking actual performance against targets throughout the life of the project, during construction and through the operational life of the completed facility. It includes:

- external benchmarking – assessing the client's performance against other major purchasers of construction through participation in a number of benchmarking initiatives
- a framework for performance measurement – including primary core performance measures that compare performance of the client's projects with that of the construction industry as a whole
- Secondary measures that compare different projects in the client organisation, including the number of changes to project requirements, final cost against initial estimate and end-user satisfaction.

Productivity benchmarking was the subject of many research efforts conducted in construction companies from the thirties of 20th century. In Czechoslovakia the Bata's Zlínská stavební Inc. had in 1936 a very progressive normative base of about 30 000 construction processes with the values of price, costs, labour consumption and productivities. In the US the early available studies since 1939 had as primary goal to assess changes in labor requirements and the impact of construction expenditures on employment. However, in practice, properly measuring productivity is difficult due to a lack of professional and academic consensus on appropriate measurement techniques and the meaning of the findings.

The last twenty years many studies have attempted to improve construction performance measurement via different ways of labour productivity examination: studying the factors affecting construction labour productivity (Thomas 1991, Thomas 1992 ,Thomas 1995, Abdel-Razek 2004); measuring and evaluating labour productivity (Abdel-Razek and A. Hosny 1990 , Abdel-Razek 1992, Hosly and Abdel-Razek 1992, Osman and Abdel-Razek 1996, Halligan 1994, Thomas and Raynar 1997) modelling construction labour productivity (Adrian and Boyer 1976, Adrian 1987 ,Abdel-Razek and McCaffer. 1990) and comparing labour productivity based on economic considerations or costs (Thomas and Zavrski 1999).

In recent years, lean construction principles have received much attention as a modern way to improve construction performance and labour productivity. Benchmarking has become an important research function in the national and global construction market. In 1999 Thomas and Zavrski (1999) developed the framework for international labour productivity benchmarks of selected construction activities. The application of these benchmarks can lead to evaluating the labour productivity and identifying the best and worst performing projects. Benchmarking of labour productivity is one of the most important lean construction principles that will be examined in this paper to show their impact on labour performance and will be implemented the model in some construction projects in Greece.

Lean construction

The word lean was defined by Howell (2001) as "Give customers what they want, deliver instantly, with no waste." One of the main objectives of lean production is to eliminate non value-adding activities, "waste", in production process (Koskela 1992). According to Koskela (1992), wastes include overproduction, waiting, transporting, inspection, inventories, moving, and making defective parts and products. In contrast to the craft and mass production, lean production combines the advantages of both. It provides volumes of a variety of products at a relatively low cost by using resources of multi-skilled workers at all levels of organisation and highly flexible, increasingly automated machines (Jeong 2003). Results from the application of this new form of production management to construction are reported in Howell (1999). Lean construction is a new way to manage construction.

Lean construction principles

The lean construction system sees production as a system of material, information, equipment, and labour raw material to the product. In this flow, the material is converted, inspected, waiting or moving. Processing represents the conversion aspect of production; inspecting, moving and waiting represent the flow aspect of production (Koskela I. 1992). In essence, the new model consists of conversions. The overall efficiency of production is attributable to both the efficiency of the conversion activities performed, as well as the amount and efficiency of the flow activities. While all activities expend cost in time, only conversion activities are Value-adding activities Tommelein (1998). The core idea of lean construction is to reduce or eliminate non value-adding activities and increase efficiency of value-adding activities. According to Ballard and Howell 1994a, 1994b. 1998, and Thomas et al. 2002, the principles of lean construction include:

(a) Practice just-in-time (JIT).
(b) Use pull-driven scheduling.
(c) Reduce variability in labour productivity.
(d) Improving flow reliability.
(e) Eliminate waste.
(f) Simplify the operation.
(g) Benchmark.

In 1999 Thomas and Zavrski developed a site-based model for measuring the labour productivity of construction activities called the theoretical (conceptual) model for international benchmarking of labour productivity (Thomas and Zavrski 1999). This model was an analytical approach to compare labour productivity in one project to that of another.

Benchmarking and components of conceptual benchmarking model

The following sections describe benchmarking as the idea of measuring and comparing an organization's business process against business leaders anywhere in the world to gain information which "will help the organization to take action to improve its performance" (Koskela 1992, Osman and Abdel-Razek 1996, Madigan 1997, Olomolaiye, 1998). Benchmarking can be internal, external, classic, traditional, process, performance, functional, strategic or a combination. The idea behind each is the same: to identify, measure, compare, perform gap analysis, adapt and implement new ideas (Fisher 1995, Osman and Abdel-Razek, 1996).

The components of the conceptual benchmarking model are productivity measures and project performance parameters explained in the following sections. Project (labour) productivity is measured under the assumption that the construction operation is a closed system with all factors held constant except for the known input (labour) and output. This value is often called physical labour productivity or unit rate (Thomas 1994).

Project attributes

The project (labour) productivity measures include: cumulative productivity, disruption index, baseline productivity, project performance parameters such as performance ratio project management index and Project Waste Index.

The cumulative productivity is defined as:
Cumulative Productivity = Total Work Hours Charged to a Task/Total Quantities Installed

Cumulative Productivity can be used in order predict the final productivity rate upon completion of the activity.

The disruption index is defined as:
Disruption Index (DI) = Number of Abnormal (Disrupted) Work Days/Total Number of Work Days

The best or maximum productivity during a particular project is called the baseline productivity which represents the best productivity that a contractor can achieve on that particular project because there are few or no disruptions. The baseline productivity is based on the 10% of workdays that have the highest output.

The performance ratio is defined as:
Performance Ratio (PR) = Actual Cumulative Productivity/Budgeted Productivity

The project management index is a normalized index which is measured as:
Project management index (PMI) = (cumulative productivity – baseline productivity)/ baseline productivity

This makes it a measure of waste The project waste index is measured as:
Project waste index (PWI) = quantity of material ordered– Quantities Installed During the Period (quantity of material ordered).

Application

The required data were obtained from small building projects in Western Macedonia Greece.

In the first project the project area is an amphitheatrum project in Florina Western Macedonia of a total area of 430 square meters to be utilized for community and educational purposes. The study is concerned for the concrete enterprise operation and is indicative for the calculation of these indices.

In the second project the project area is a typical office building construction project in the area of Kozani Western Macedonia of a total area of 1021 square meters to be utilized for educational purposes. The study is concerned for the concrete enterprise operation and is indicative for the calculation of these indices.

In the third project the project area is a typical educational building construction project in the area of Florina Western Macedonia of a total area of 850 square meters to be utilized for educational purposes. The study is concerned for the concrete enterprise operation and is indicative for the calculation of these indices.

Finally in the fourth project the project area is a typical building construction project in the area of Western Macedonia of a total area of 1021 square meters to be utilized for residential purposes. The study is concerned for the concrete enterprise operation and is indicative for the calculation of these indices.

	Project Name	Type of Project	Type of contractor	Work days	Location
1	Amphitheatrum	Public	D	420	Florina
2	Offices	Educational	D	170	Kozani
3	Classrooms	Public	E	220	Florina
4	Dormitories	Residential	E	180	Florina

Table 1. **Examined Project areas**

Day	Crew size	Work hours	Baseline days	Abnormal days
1	2	16	*	
2	4	28	*	
3	4	28	*	
4	2	14	*	
5	6	40	*	
6	2	16		*
7	4	32	*	

Table 2. **Part of Data of one case study**

In this research data were gathered in terms of Daily Work Hours, Daily Quantity, and Work Hours Charged during the Period, Quantities Installed during the Period, Total Work Hours Charged to a Task, Total Quantities Installed, and quantity of material ordered.

The above mentioned data are presented in the following Table.

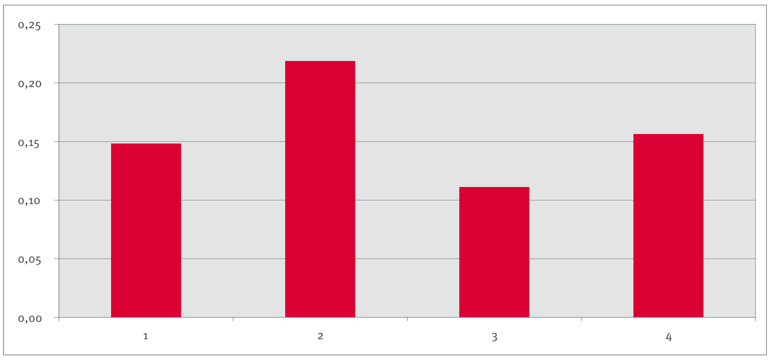

Figure 1 **Disruption Index of the application**

Project	1	2	3	4
Daily Work Hours	8	8	8	8
Work Hours Estimated During the Period	367	199	254	256
Work Hours Charged During the Period	432	256	288	296
Quantities Installed During the Period	2468	899	1267	1089
Total Work Hours Charged to a Task	1320	765	546	854
Quantity of material ordered	3432	978	1467	1280
Number of Abnormal (Disrupted) Work Days)	8 (days)	7(days)	4 (days)	5(days)
Total Number of Work Days	54	32	36	32

Table 3 **Data from the construction projects**

Results

The project sustainability measures for the first project area are calculated as follows:

Actual Cumulative Productivity
0.24 (=256 hrs/1089)

Disruption Index
0.16 (=5days/32days)

Baseline productivity
0.24 (=132x8hrs/1089)

Performance ratio
1.15 (=0.27/0.24)

Project management index
0.31 (=0.27-0.24)/0.27

Project Waste Index
0.14 (=(1280 m3-1089 m3)/1280 m3)

In the following paragraphs the measures for all the project areas are examined.

Disruption index (DI)

The values of DI range from 0.1 to 0.23. The higher the DI, the more the project experienced abnormal work days. This can be attributed to the number of abnormal days during the winter season .

Performance ratio (PR)

The performance ratios of the studied projects are calculated and presented in Figure 2. The PR ranged from 1.14 to 1.28. It should be noted that the lower the PR the better the performance. A PR value greater than 1.0 does not necessarily mean a poorly performing project, but rather is a comparison against the best overall performance.

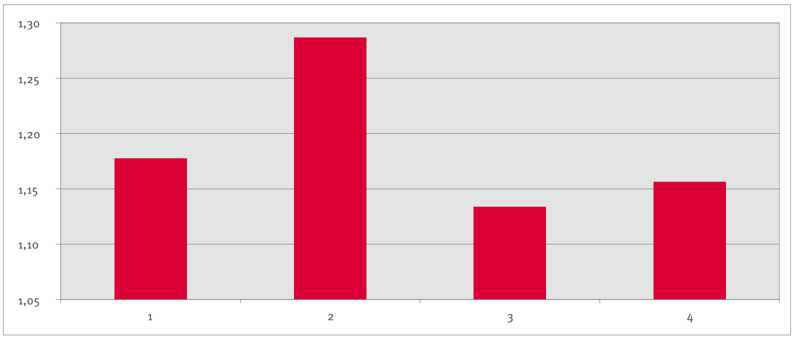

Figure 2 **Performance ratio of the application**

Project Management Index (PMI)

The PMI compares the actual cumulative productivity to the baseline productivity.

As PMI is a measure of the difference between the actual and baseline productivity, it provides a measure of the impact of poor material, equipment, and information flows and inadequate planning. The PMI is a dimensionless parameter that reflects the contribution of project management to cumulative labour performance on the project. The lower the PMI, the better was the project management's influence on overall performance. The PMI values ranged from 0.11 to 0.23 and are summarized in Fig 3. As shown project 2 has PMI values >0.2 i.e. 25% of the studied projects performed rather poorly. The management of that particular project had a low influence on labour project productivity. The low management influence during the project construction as expressed by the difference of cumulative productivity minus baseline productivity is attributed mainly to the adverse weather conditions during the construction period.

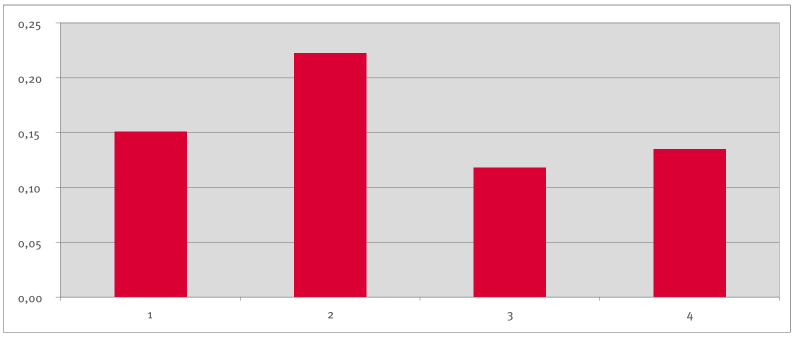

Figure 3 **Project Management Index (PMI) of the application**

Project Waste Index (PWI)

This makes it a measure of waste. The PMI is directly related to the project waste index (PWI). Reduced waste can lead to better productivity. PMI ranged from 0.08 to 0.27. (The quantity of materials used was from 8% to 27% higher than the quantity of materials installed).

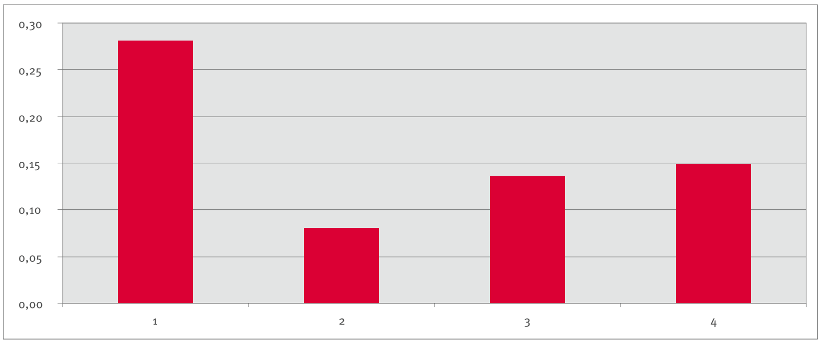

Figure 4 **Project Waste Index (PWI) of the application**

Conclusions

The paper examined benchmarking as lean construction principle in labour productivity and consequently in project performance. Using labour productivity data from small projects in Greece the benchmarks of labour productivity were calculated. The benchmarks are the disruption index (DI) performance ratio (PR) and project management index (PMI). They are used to identify the performance of projects. The values of DI range from 0.00 to 0.23. The higher the DI, the more the project experienced abnormal work days. This can be attributed to the number of abnormal days during the winter season that cause the construction work to fall behind schedule with significant effect on the quality of the work. These projects have a small value of PMI that reflects small contribution of project management to cumulative labour performance on the project and low values of performance (PR values) and wastage (PWI values). The results showed that lean management is an important tool for project and construction management Findings of this research can be used not only for the assessment but for the control of construction projects. Construction managers may use the above measures for controlling the projects as a usuful information for correcting the projects' performance which the innovation of this research. This paper outlines some key institutional barriers to achieving this potential. Indices representing the above criteria are introduced to express in quantitative terms productivity as well as material and equipment utilization. Concepts of adaptive management or 'learning by doing' utilizing these criteria are being tested in a study construction projects West Macedonia Greece. There is need to establish one European international normative base of construction processes based on a normative base system (e. g. on DIN or Czech/Slovak normative base system) and update it with actual values of productivity of construction processes gained on building sites. This could be used as a base for budgeting, cost calculating and project planning systems in whole Europe. The above indices can then be incorporated with Computer Construction Systems to assess and control labour productivity after or during the construction phase of a project. Conclusively the proposed indices can contribute to improve project management index: management influence (filling the gap between cumulative and baseline productivity) and design influence (baseline productivity). Further research into other lean construction principles i.e. variability in labour productivity should be applied in order to improve overall project performance.

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