USING PRODUCTIVITY INDICES IN ADAPTIVE CONSTRUCTION PROJECT MANAGEMENT

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Abstract

In recent years there has been a rising interest in the level of productivity in the construction industry. This can be attributed to the fact that weak productivity growth in the economy as a whole is reflected in the construction industry. The purpose of this paper is to review various measures of productivity used in the literature, such as the Project Management Index and Disruption Index that have been used to determine the levels of productivity as well as to analyse some of the results so far in Greece. The method introduced in this research is adaptive management as an approach to more closely link research with construction project management. A case study is considered, for the purposes of this research. The Project Management Index as well as and the Disruption Index are calculated both for the traditional method and the adaptive method. The Project Management Index derived is as high as 0.1 based on the traditional method while it is 0.0083 based on the adaptive method. The Disruption Index based on the traditional method is 0.092 while based on the adaptive method it is as low as 0.047. Conclusively, project management benefits from using the adaptive process in construction activities.

Key words

Adaptive management; project management; productivity indices; construction management

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1 INTRODUCTION

Labour productivity is defined as the hours of work divided by the units of work accomplished. This value is often called physical labour productivity or unit rate.

The main problems in the construction industry are: its declining rate of productivity and lack of productivity standards. There is no standard definition of productivity measurement and any current misunderstandings about it appear to stem from nonstandard terminology.

The need for a better productivity measurement, materials and equipment utilization arises from the relatively new concept of sustainable development, especially in areas of Greece. If this is the case, performance monitoring is seen as an adaptive approach to more closely link sustainability with project productivity and 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 through external benchmarking, a framework for performance measurement that compares the performance of the client's projects with that of the construction industry as a whole and secondary measures that compare different projects in the client's organization, including the number of changes to project requirements, final cost against initial estimates and end-user satisfaction [1]. Delays are a common problem, specifically for projects by the Greek state (public works) and can become indebted due to unanticipated factors (e.g., natural destructions, negative developments in the economy, etc.) or in bad planning, in insufficient control and insufficient administration. Excessive costs also lead to a reduction of profits or a waste of the financing party's economic resources, as well as poor productivity.

Therefore, there is a need to improve the understanding of how a system works so as to achieve management objectives. Models are used to incorporate assumptions about the behaviour of the system and allow managers to predict the impact of their activities. After the activities have been performed, the underlying assumptions of the models should be checked against monitoring data, providing a foundation for learning and improving the management, based on the knowledge that has already been acquired. These predictions are the basis for later learning using adaptive management.

However, adaptive project management has not been applied in measuring construction productivity where there is a high level of uncertainty involved. The aim of this work is to use adaptive project management to measure productivity in engineering problems caused by the uncertainty of projects. The related indices used are two characteristic indices, namely the Project Management and the Disruption Index.

2 LITERATURE REVIEW

Many studies have attempted to improve construction performance measurement with different ways of examining labour productivity: studying the factors affecting construction labour productivity [1], [2], measuring and evaluating labour productivity [3], [4], [5], [6], [7], modelling construction labour productivity [8], [9], and comparing labour productivity based on economic considerations or costs [10].

According to Thomas and Zavrski [10], productivity is the median of the daily productivity values in the baseline subset. El-Gohary and Shehata [11] use a productivity measurement which is slightly different from the method used by Thomas [12] where the mean of subset productivity is used in this study instead of the median. Ibbs [13] introduced a new method called "K-means clustering" for productivity calculation that overcomes such weaknesses.

Ibbs and Liu [14] also introduced a series of guidelines that can be used by contractors, consultants, owners and other interested parties, to develop and apply measured miles to quantify the loss of labour productivity. Thomas [12] introduced data envelopment analysis (DEA) as a new method for deriving productivity. They compared it with the other four productivity deriving methods.

Adaptive management was originally developed by ecologists. Ecosystems are complex and dynamic. Therefore, our understanding of ecosystems and their ability to predict how they will respond to management actions is limited [15]. Along with changing social values, these gaps in knowledge are the cause of uncertainty about how to best manage resources [16]. Despite these uncertainties, resource managers must make decisions and implement plans. Adaptive management is a way for resource managers to proceed responsibly to address this uncertainty [17]. It provides a good alternative that can eliminate bad management options that have social, economic and ecological impacts. Adaptive management is designed to improve understanding of how a system works, so as to achieve management objectives. The concept was introduced by Frederick Taylor in the early 1900s [18], [19].

3 METHODS

There are numerous factors which influence labour productivity. These factors could merely be management related factors. The main problems that occur during a project, the ones that the implementing team has to face effectively, are delays and management factors.

Management related factors include: (1) the level of on-site management and coordination; (2) workmen's job security; (3) labour experience; (4) workmen's long-term pacing; (5) breaks in the work. Other management decisions that significantly affect labour productivity are decisions related to the flow of men and materials on the jobsite. However, these actions are particular to the job conditions encountered.

In this research in order to perform a quantitative analysis, the MS Project was used to simulate the alternatives considered and calculate the corresponding indices as follows:

The Project Management Index is defined as:

PMI – Adaptive Method

Project Management Index (PMI) = (cumulative productivity – baseline productivity)/ baseline productivity where

Cumulative Productivity = Productivity based on the adaptive method within an implementation time of 277 days and a constant amount of workload = total work hours / total quantities installed

Baseline Productivity = Total work hours / total quantities installed

PMI – Traditional Method

Project Management Index (PMI) = (cumulative productivity – baseline productivity)/ baseline productivity where

Cumulative Productivity = Productivity based on the traditional method within an implementation time of 291 days and a constant amount of workload = total work hours / total quantities installed

Baseline Productivity = Total work hours / total quantities installed

The Disruption Index is defined as:

DI – Adaptive Method

Disruption Index (DI) = Number of abnormal (disrupted) work days / total number of work days, therefore:

DI = 13 /277 =0.0469

DI – Traditional Method

Disruption Index (DI) = Number of abnormal (disrupted) work days/ total number of work days, therefore:
DI = 27 / 291 = 0.092

CASE STUDY

The data collection concerns the building activities of a construction project in Greece during the time frame 14/05/2012 to 03/06/2013. The projects' Gantt chart of the planned and the actual schedule areas is as follows:

The planned schedule is derived using Microsoft Project. This process takes place during the planning phase.

Fig. 1 goes here

According to the planned schedule, the estimated finishing time of the project is after 264 working days and the budget is €410,260.

These figures are used as a baseline for changes affecting the time and budget.

In Figure 2 the final schedule is presented due to unforeseen changes to the project.

Fig. 2 goes here

It is assumed that the delays to and the consequences for the project are as follows:

1. During the laying of the foundations, which involves pouring concrete, a sudden storm occurred, causing the excavated earth to fall in, which delayed the work by four days. The consequence of this was that three workers had to work to re-establish the previous work undone by the damage, increasing the total cost of the work to 810 euro. Furthermore, because that particular activity is particularly critical, it also had repercussion in the initial planning, delaying the concrete pouring by four weekdays.

2. The increase of the cost of electrical materials was about 10%. The consequence of this was to increase the total cost of the work by 1,950 euro but did not influence the initial time scheduling.

3. A delay in receiving a receipt for the plumbing material cost about found days, which did not influence the minimal flow of the project, as that particular activity is not critical. Furthermore, the delay in receiving the receipt is not influenced by the cost of the project.

4. Theft of materials (tiles) and specifically tiles influenced the total cost of the work by about 5,000 Euros. Because the supplier did not allocate a reserve fund and ordered from abroad, the loss of work floorings and scales delayed the project by nine days. That particular activity is critical, so it influenced the project with a delay of nine days and the time needed for the finalization of the work.

5. The delay from lack of attendance on the part of the mason's crew cost the project five days. This did not influence the minimal flow project, as that particular activity is not critical.

4 RESULTS

With the use of the indicators, PMI and DI, the productivity for the adaptive method and traditional method are calculated as follows:

PMI – Adaptive Method

PMI = (11672 / 11576) - 1 = 0.0083

PMI – Traditional Method

PMI = (12734 / 11576) - 1 = 0.1

DI – Adaptive Method

DI = 0.047

DI – Traditional Method

DI =0.092

In this point we would like to compare the above indices with a similar study which also uses a similar method in predicting project performance. Idiake, J E and Bala [20], analyse labour output for masonry work in the construction of six bungalow buildings in Abuja metropolis in Nigeria. The PMI values calculated for the studied project ranged from 0.0106 to 0.194. Three of the projects had PMI values lower than 0.1 which is an indication of good performance and three had values greater than 0.1. The DI values calculated for the studied project ranged from 0.000 to 0.625. It should be noted that the lower the DI the less the project witnessed irregularities in work days.

5 DISCUSION OF RESULTS

In Table 1 the divergences that resulted in the completion of the work in terms of time and cost are presented. In the line "Traditional method" the real divergences from the completion of the work are presented. With the use of indicators of productivity, we can reach a number of conclusions.

Thus we have:

Tab. 1: Calculation cost at time of completion PMI – DI

	Cost at Completion (€)	**Time of Completion (days)**	**PMI**	**DI**
Initial Programming	410.260	264		
Adaptive Method	418.020	277	0.0083	0.047
Traditional Method	451.286	291	0.1	0.092

According to the results of Table 1, the adaptive method is better than the traditional in terms of PMI. (The lower the indicator PMI, the better it is). As the indicator DI is concerned we observe that the adaptive method is also better than the traditional (the lower the DI the less the project witnessed abnormal work days).

In Table 2 the percentage of divergences that resulted at the completion of work in terms of time and cost are presented.

Tab. 2: Percentage of divergences at the completion of work in terms of time and cost

	Cost	**Time**
Adaptive Method	7.760€/+1,9%	13 Days/+4,9%
Traditional Method	41.026€/+10%	27 Days/+10%

As seen in Table 2, when the methodology of adaptive project management is put into practice, the real cost of work results in an improvement of 1.9% in the budget at the study phase, while the real time delay of 13 days increased by 4.9%. Thus, the householder saves 33.266 euros. Furthermore, the work was delivered 14 weekdays earlier than with the traditional method.

6 CONCLUSIONS

This paper presents the possibility of implementing a specific project in Greece with the methodology of adaptive project management. This methodology is used mainly in large and complex systems such as ecosystems, in which the impacts of an intervention cannot be predicted. It presents the basic steps for the construction phase of the technical project and includes its budget and timing. Then, we assume that some delays during the implementation of the construction will occur, of which some are crucial and some are not for the scheduling and the cost of the construction. It uses labour productivity data from this project in Greece and the benchmarks of labour productivity were calculated for each project management method and a comparison of these was performed. The benchmarks are the Disruption Index (DI) and the Project Management Index (PMI).

The PMI calculated based on the traditional method is 0.1 while when based on the adaptive method it is 0.0083. Thus, since the lower the PMI, the better the result is, the adaptive method predominates here over the traditional method. According to Idiake and Bala (2012), three of the projects had PWI values lower than 0.1 which is an indication of good performance and three had values greater than 0.1.

The DI under the traditional method is 0.092 while based on the adaptive method it is 0.047. So given that the higher the DI, the more days are delayed, we concluded that the adaptive method outperforms the traditional method. According to Idiake and Bala [20], the DI values ranged from 0.000 to 0.625 with four of the projects having experienced zero irregular days which means the projects performed well on the basis of no disruption.

This paper examines the perspective of implementing adaptive management in an average-sized, commercially widespread technical project, to which any possible change can be calculated, even though this specific method is widely used in systems without measurable indicators. Based on the results, the conclusion is that this method can be used efficiently, because its total benefits, such us the cost of construction and the timetable produced, are crucial.

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