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Research Article

Determining the Factors Affecting the Productivity in Construction Projects

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ARTICLE INFO

Article history:

Received 16 February 2022
Received in revised form 4 August 2022
Accepted 5 August 2022
Available online 30 September 2022

Keywords:

Productivity, Duration, Extension of Time, Delay, Construction

Doi: 10.24012/dumf.1074842

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ABSTRACT

Construction projects are sophisticated in nature and require close attention and project management techniques to complete projects on time by monitoring and controlling the project resources. Productivity is one of the significant factors affecting the project life-cycle in terms of time and cost. In this study, actual productivities of construction tasks such as gypsum board, suspended ceiling, ceramic, gypsum plaster, satin plaster, paint and thermal insulation board were determined at one of the Research and Training Hospitals in Istanbul. The site records were obtained from the daily reports reported in February, March, April and May. The laborers working for the concerning tasks worked 8 hours a day. Afterwards, the actual unit man-hour data for each activity obtained from the project reports were compared with the planned man-hours and unit man-hour data provided by the Ministry of Environment and Urbanization. In the wake of the comparison of planned unit manhour, actual unit manhour and unit manhour obtained from ministry, the factors affecting productivity were examined and necessary suggestions were made in order to improve productivity domain in the practice.

Introduction

Projects are defined as unique attempts to achieve the intended goals with the help of the effective use of limited resources by ad hoc organizations [1]. The organizations of construction projects are very complex and thus are prone to delays. When projects are delayed, contracting parties seek their rights according to the Extension of Time (EOT) provision of the project contract. An extension of time (EOT), usually requested by the contractor, is a provision in most standard contracts that refers to the extension of the project's planned completion date due to unforeseen circumstances. Extension of time (EOT) mostly ends up with dispute among the contracting parties and results in further time and cost overrun [2]. Due to the importance of the prevention of any delay in construction projects, resource utilization comes into prominence; therefore, construction firms have to use their resources more efficiently than the other competitors in order to complete the projects on time and within the budget to provide a strategic advantage against the other competitors and to ensure the sustainability of the firm [3]. The productivity values - which are learned from their previous projects - can help the companies to increase their profitability in their upcoming projects by reducing the waste in the works. Minimizing waste in construction companies also contributes to the development of the economies of the countries [4]. In order to complete the project within the scope of the contract and expected time and budget, the correct determination of the number of resources and effective and efficient management of the resources are required. In order to compute the activity durations correctly, labor productivity should be forecasted accurately. Productivity values can change according to many factors such as the dynamics of the projects, the type of contract, and the type of project management. Today, the majority of projects experience delays [5]. For this reason, accurate determination of labor productivity is of vital importance in terms of completing the project on time. Delay is one of the main reasons that negatively affect the dispute, and its timely resolution plays an important role in maintaining business relations in the construction industry and providing the planned benefits from the projects. However, most construction projects fail to settle the time-related disputes [3–5], and this everlasting problem has taken the researchers' attention to focus on the studies proposing solutions to overcome the time-related disputes. There has been rising interest in studies focusing on the delay analysis domain with different aspects. While some researchers detected

the sources of time-related disputes to diminish or thwart the disputes in the projects [6–8], other researchers have concentrated on the productivity domain to ensure the project activities and project duration are completed on their due date. Many researchers stressed the need for realistic estimation to increase productivity in the construction industry [6], [7]. There are many factors affecting labor productivity in the construction sector [8]. For this reason, many studies have been conducted concerning productivity. Productivity can be defined as the relationship between the output which is produced by production or service and the input which is required to create the output. Dikmen et al. [9] stated in their study that wind direction affects productivity in high reinforced concrete structures. Sevim and Kuruoğlu [8] studied how formwork, reinforcement, concrete and masonry works are affected by weather conditions (temperature, relative humidity and wind speed). Erdiş et al. [10] conducted a study concerning productivity in the workforce such as rebar and stated that team profile, type of resources used in the project, indoor/outdoor environment conditions, psychological conditions and vocational training affect worker productivity. The Ministry of Environment and Urbanization annually publishes labor productivity values for various construction works. These values - which are taken as a reference by many organizations - were verified by Kuruoğlu and Bayoğlu [11] via a case construction project. Differences were observed between the values of the Ministry and the values that emerged as a result of the study, and they suggested that these values of the ministry should be updated. Factors Affecting Construction Labor Productivity have been determined by many researchers [12]–[15]. However, none of the studies have focused on the cause of the productivity changes. This study aims to determine labor productivity and the main factors affecting productivity through a case study. In this study, the productivity values of the workers in a research and training hospital project in Istanbul were measured for 4 months. The productivity of the workers working for the production of gypsum board, ceramic, suspended ceilings, gypsum plaster, satin plaster, paint and thermal insulation boards in construction works were determined. The productivities of the laborers – who work 8 hours a day - were measured by dividing the total working hours of the workers spent for each activity by the total amount of work produced in 4 months. Planned and actual productivity values obtained from the case project were compared with the concerning productivity provided by the Ministry of Environment and Urbanization and significant inferences were made to detect the causes of fluctuation in productivity in construction projects. It is highly believed that this study will pave the way for future studies concerning detecting factors affecting the fluctuation of labor productivity. Additionally, this study is believed to shed light on the improvement of labor productivity value of The Ministry of Environment and Urbanization. The scope of the study is limited to the research and training hospital project in Istanbul, Turkey.

Productivity

Productivity is a measure of how well resources are used and it is calculated as the ratio between the inputs (labor, resources) and the outputs (goods, services). Productivity can also be computed in the works with more than one input and output. For these cases, multi-item productivity and total productivity analyses can be made [16], [17]. The representation of the computation of the productivity is summarized as depicted in Table 1 below.

Table1. Type of Productivity Methods

Type of Productivity	Equation
Partial Productivity	Output / A Single Input
Multi-Factor Productivity	Output / Multiple Inputs
Total Productivity	Output / All Inputs

The productivity equations - which are represented as output/input defined in Table 1 - can also be represented as input/output. In the construction industry, the equation concerning manhour/unit - which is generally described as partial productivity - is used to measure productivity. By the same token, this formula also expresses the unit labor time required for one unit of production. These values can also be obtained from the experiences of the companies' former projects, expert opinions and various sources such as the Unit Price Analysis of the Ministry of Environment and Urbanization [11], [18]. However, since the productivity values may vary from project to project, the assumed productivity values can be adjusted to the relevant project with the help of an expert opinion.

Methodology

In this study, productivities of the finishing work such as gypsum board, suspended ceiling, ceramic, gypsum plaster, satin plaster, paint and thermal insulation board at the research and training hospital in Istanbul were determined by measuring the workforce and production of the concerned laborers. The data were obtained from the daily construction site progress reports generated in February, March, April and May. In the daily construction site progress reports, detailed job definitions were made for each work item according to daily productions. The unit man-hour values are computed as depicted in Equation 1 below.

$$\frac{\sum_{i=1}^{n}(Labour\ working\ hour\ )}{\sum_{i=1}^{n}(Unit\ )} \quad (1)$$

In Equation 1, while n stands for the number of the working day of the laborers, the unit represents daily production amounts. The concerned laborers worked 8 hours a day and their daily production values and the number of workers employed were reported from the field with the help of daily reports. Afterwards, the planned and actual unit man-hour data for each activity obtained from the project reports were compared with the unit man-hour data provided by the Ministry of Environment and Urbanization. Unit manhour amounts of each sub-item of the concerning activities in the analyses were summed in order to calculate the unit manhour value for the

concerning activities in the Unit Price Analysis of the Ministry of Environment and Urbanization. As a result of the comparison of planned, actual and ministry data, the factors affecting productivity were examined.

Results and Discussion

Productivity values were measured from February to May in the research and training hospital project in Istanbul, and the findings are depicted in Table 2 below.

Table 2. Findings concerning productivity

Work	Unit	Total Unit	Daily Report Data (Total Monthly Unit)				Manhour / Unit
			February	March	April	May	
Gypsum Board	m^2	25,630	3,420	6,650	7,975	7,585	0.60
	manhour	15,288	3,960	3,688	3,848	3,792	
Suspended ceiling	m^2	30,970	5,945	8,605	9,760	6,660	0.59
	manhour	18,416	4,112	4,104	4,704	5,496	
Ceramic	m^2	16,691	3,976	6,108	3,325	3,282	0.93
	manhour	15,480	4,592	4,680	2,936	3,272	
Gypsum Plaster	m^2	7,935	1,570	2,150	2,745	1,470	0.61
	manhour	4,824	1,208	1,496	1,464	656	
Satin Plaster	m^2	85,055	15,850	11,000	26,845	31,360	0.31
	manhour	26,200	4,896	4,888	8,776	7,640	
Paint	m^2	35,150	8,000	1,160	8,120	17,870	0.16
	manhour	5,624	920	608	1,224	2,872	
Thermal Insulation Board	m^2	2,550	640	1,210	700	-	1.12
	manhour	2,848	600	1,464	784	-	

Productivity values (manhour/unit) which were determined during the planning phase of the training and research hospital project, actual productivity values which were determined with the help of the daily construction site progress reports and the productivity values which were obtained from the Unit Price Analysis of the Ministry of Environment and Urbanization are compared in Table 3.

When the tables involving unit manhour values determined during the planning phase of the project and the unit manhour values computed through the daily construction site progress reports are compared, it is detected that the planned and actual productivity values are very close to each other. As is seen in Table 3, the actual productivities are better (lower) than the planned productivities except for gypsum plaster and satin plaster works. It was interpreted as that the subcontractors of these activities deliberately assigned the higher unit man-hour values in order to offer a higher price in their tender.

When the actual productivities of the concerning activities are compared with the unit manhour values of ministry, it is determined that the actual labor productivities are better because the project accommodated the skilled workers who have received a professional qualification certificate, which was clarified by supervisors of these workers. When the actual productivities concerning gypsum board, suspended ceiling and paint are compared with the productivity values of the Ministry of Environment and Urbanization, it is seen that the actual productivities are far ahead.

Table 3. Productivity comparison table

Activities	Unit manhour values			Ministry of Environment and Urbanization Item Number
	Planned Values	Actual Values	Ministry Values	
Gypsum Board	0.80	0.60	2.80	15.530.1005
Suspended ceiling	0.60	0.59	3.00	15.530.1131
Ceramic	1.10	0.93	1.20	15.380.1056
Gypsum Plaster	0.40	0.61	0.70	15.280.1008
Satin Plaster	0.13	0.31	0.55	27.528/3
Paint	0.60	0.16	0.78	15.540.1225
Thermal Insulation Board	1.20	1.12	1.20	15.345.1106

Conclusion

Measuring labor productivity in construction projects is very vital for companies to gain a competitive advantage and increase profitability by reducing waste. Productivity is one of the indispensable elements of project management for the issues such as calculating the total duration of the projects, calculating the total labor costs in tenders and balancing resources within the project. In addition to the success of enterprises, labor productivity is essential for the growth of the economies of the countries and the increase in the level of welfare. In this study, labor productivities for the aforementioned activities were measured and computed in the case project in a comprehensive manner over 4 months. The actual productivities were compared with the planned values of the project and the values obtained from the Ministry of Environment and Urbanization. It has been determined that the actual labor productivities concerning gypsum board, suspended ceiling, ceramics, gypsum plaster, satin plaster, paint and heat insulation board coating are higher than values obtained from the Unit Price Analysis of the Ministry of Environment and Urbanization. Based on this result, it is clear that the data of the Ministry of Environment and Urbanization should be revised because they are too high. It is inferred from this case study that the unit manhour values concerning planned gypsum board, suspended ceiling, paint, ceramic and thermal insulation board are higher than the actual productivity values. The main reason for this was detected as the tendency of the subcontractors to give high labor prices at the tender stage. In this case, it is concluded that it is important for the owner to control the productivity values of the contractors and subcontractors in order to achieve the most accurate tender offer. In the study, it was observed that the working environment and camp conditions of the workers working in the production of satin plaster and gypsum plaster were poor, and the workers' wages were not paid on time. For this reason, it has been concluded that the planned unit manhour values are less than the actual unit manhour values. It is highly believed that this study will contribute to the literature concerning the factors affecting the fluctuation of labor productivity. Furthermore, this study is believed to guide The Ministry of Environment and Urbanization to improve labor productivity values. The scope of the study is limited to works such as gypsum board, suspended ceiling, ceramic, gypsum plaster, satin plaster, paint and thermal insulation board; therefore, other construction works should be examined in the other studies to guide the practitioners and Ministry of Environment and Urbanization. Furthermore, this research has also a limitation that it was conducted in a training hospital project in Istanbul, Turkey. Other case studies can be conducted to further validate the outcomes of this study.

Ethics committee approval and conflict of interest statement

There is no need to obtain permission from the ethics committee for the article prepared

There is no conflict of interest with any person / institution in the article prepared

Authors' Contributions

Çevikbaş M: conducted all study in the manuscript

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