Economic Conditions of Leaving the Construction Site by the Contractor at Different Stages of its Implementation

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Abstract. The article attempts to carry out a detailed economic analysis resulting from the interruption of works executed on the basis of the agreed work schedule. The event of the contract breach by the contractor may result from the identified underestimation of the works at the stage of their valuation, or from diagnosed delays in implementation, not allowing for their timely completion. The decision to discontinue the works is usually preceded by an analysis of the costs necessary to incur, generated by contractual penalties for failure to perform the contract. The comparison of the costs of contractual penalties with the actual expenses for the implementation of the project should also include the actual delay of works, as it generates additional financial losses. The economic analysis of the contractor's leaving the construction site was carried out using the tools of the Earned Value Method (EVM), using its simple and complex indexes. The case study concerns the assessment of costs and the actual pace of works implementation on the construction site – at various stages of their implementation according to the agreed schedule. The aim of the analysis is an attempt to identify the level of production executed on the construction site, at which its non-profitability takes precedence over the non-profitability of the contract, from the contractor's point of view. The economic analysis uses an example of a completed construction project involving the construction of a three-segment multi-family residential development in Opole (Poland).

Keywords: Economic analysis · Works scheduling · Works interruption · Earned value method (EVM) · Works monitoring · Management

1 Introduction

Organizationally effective planning of construction works is a key part of the investment process, especially in times when the time and costs allocated to their implementation play a key role. Organizational effectiveness covers a wide range of issues related to the planning and scheduling of works [6].

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The search for a scenario for the implementation of an undertaking, favorable for the contractor from the point of view of implementation costs, is a very complex issue [7]. In practice, this problem is solved on the basis of a simplified economic calculation, which only takes into account the cost characteristics determined by cost estimate analyzes. Their purpose is to evaluate organizational solutions, and not to assess the financial results of an enterprise. Performance assessment through the analysis of delays and underestimations brings lots of useful information when using standard cost accounting. The basic ones include quantity and rate variances in the cross-section of calculation items (e.g. quantitative variances of direct materials, variances of direct wages rates) [8]. The most common method of analysis is flexible budgeting, which is a tool for effective control and at the same time supporting the planning process. The second important element is the constant monitoring of works, which is in fact production control aimed at eliminating the emerging delays.

In an extreme situation, when many activities are delayed at the same time, an effective task may be to appoint a task force that will lead the remaining works [4]. However, corrective measures only work if they are taken in time. Another solution could be working overtime, which allows to gain on time. This solution can be very helpful in case of time delays. However, when they are used too often, the law of diminishing returns, associated with a decline in labor productivity, becomes apparent.

The growing number and growing importance of unique, often complex construction projects results in unflagging interest in project management [5]. Customer expectations are also growing and the pressure to shorten the time of their implementation. The economic analysis of a project is an iterative process relating to the moment of its commencement and periodic assessments during its implementation. Then, changes in the environment and the level of knowledge or the finding of serious discrepancies in relation to what was foreseen lead to a revision of the previously adopted operational strategies. With the emergence of the new *Lean Construction* theory, the old management paradigms were retained in the principles set for it [2]. At the same time, innovations have been introduced through continuous improvement to monitor construction processes. The proactive style of management led to increase the speed of reaction to changes.

As an alternative to this trend, in parallel with network techniques, the Earned Value Method (EVM), or Earned Value Analysis (EVA) technique, developed by the United States Department of Defense, was created. It became widely used in practice as a control tool indicated by *the Project Management Institute* (PMI) as a standard tool for measuring the time and cost of projects [3]. EVM consists in controlling the implementation of the project by comparing the scope of works performed to date and the deadlines for their implementation [5], and the actual costs incurred with those adopted in the schedule. Depending on the data obtained at individual stages of the project, the management of the managerial level, analyzing the results of this method, has the opportunity to take remedial measures to improve the current course of works on the construction site.

The essence of the EVM is presented in Fig. 1. The curve illustrating the course of BCWS - "Budgeted Cost of Work Scheduled (BCWS)" (scheduled costs) is determined during the project planning phase, its final value is BAC – "Budget at Completion" [9]. Curves illustrating the course of BCWP – "Budgeted Cost of Work Performed" (earned value) and ACWP – "Actual Cost of the Work Performed" (costs incurred), are

determined during the execution of the works and can be determined only until the day of the inspection. Data from the BCWS, BCWP and ACWP curves are the basis for calculating further indexes. They can be divided into two groups: indexes to monitor the progress of work (CV, SV) and indexes for forecasting further costs and work progress based on the results so far (CPI, SPI).

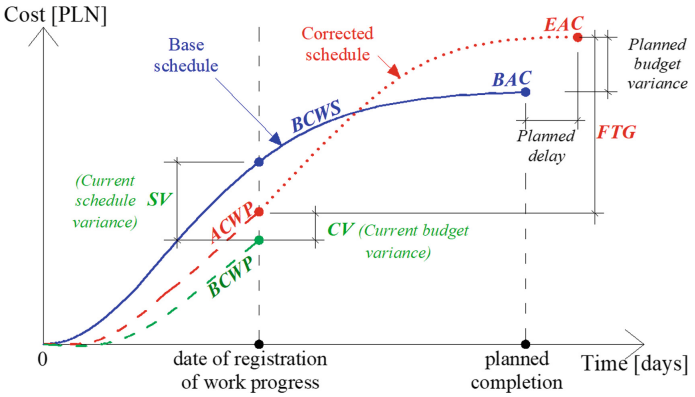

Fig. 1. Elements of EVM [10].

Project monitoring and the related decision-making process regarding the implementation of corrective actions are an important component of an integrated management system, as well as the control decision support system [1, 11, 15]. Before starting a project, managers very often use data from already completed projects when estimating cost and duration forecasts. This approach also fails, which is due to the uniqueness of construction production. The earned value method has two important advantages [9]. It allows to combine a temporary assessment of the progress of works with their financial advancement against the background of the planned values. Moreover, it enables estimating the final cost and completion date of the project on the basis of the trends revealed in its implementation so far. Like any supporting tool, this method also has its limitations [12, 16].

Despite relatively simple assumptions, the main problem is the data which are necessary to obtain in order to use them. The very collection and processing of data requires a lot of consistency and systematicity. At the stage of their analysis, problems arise due to the specificity of the building itself and the course of works. It should also be noted that the application of the method usually makes sense only in the case of projects, e.g. lasting more than a year. Only then a lasting trend can develop, allowing for a reliable estimation of the data on the completion of the project.

Due to the research carried out on over 700 large American projects, it was found that with less than 15–20% of the advancement of the works, the use of the EVM makes it possible to predict the final result with high accuracy, independently on the type of monitored project [12]. The first serious attempts to use this method took place in the second half of the 60s of the 20th century as a specialized financial analysis in large projects of US Army, commissioned by the US government [14]. In the late 1980s and

early 1990s, the EVM methodology became the most popular. Despite the passage of time, *the Earned Value Method* has not lost its importance. It is now a mandatory standard for projects financed by the World Bank, NATO, Lockheed Martin, Boeing, IBM, and other large corporations.

2 Practical Aspects of Applying the Analyzed Method

2.1 Description of the Research Object

In order to analyze the economic profitability of the works carried out, the material and financial schedule of the completed construction project was used, consisting in the construction of a three-segment multi-family housing development in Opole (Poland). The construction contract assumed the comprehensive implementation of works over a period of seven months, with the commencement on 01/03/2017 and completion on 30/09/2017. The offer cost estimate for the analyzed project was set at PLN 20,106,851.97 net. The schedule adopted for implementation assumed comprehensive implementation of the base stage for the entire development, the remaining works (overground construction, finishing works) were planned according to the uniform (stream) work method, giving the implementation rhythm equal to the duration of their main assortments. The contractual costs of contractual penalties were 0.1% for each day of delay in the final delay of the project. A 15% contractual penalty was also assumed for failure to comply with the subject of the contract.

2.2 Monitoring the Progress of Works According to the EVM

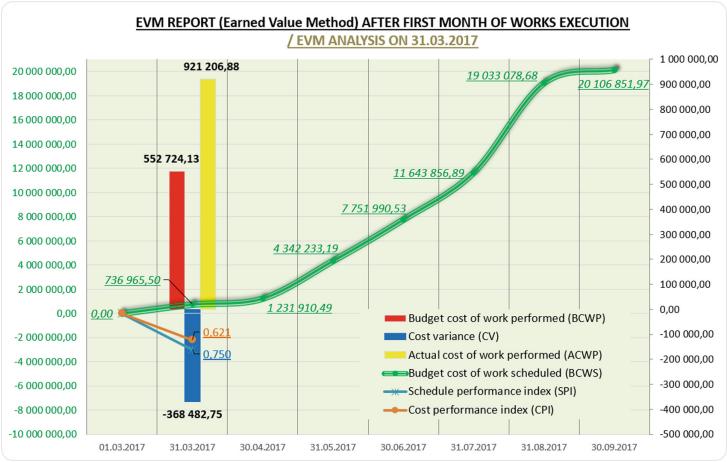

Fig. 2. Report on the progress of works executed on the construction site using the EVM: as of 31/03/2017. Source: Own research and development, calculations in PLANISTA MAX.

After the first month of the project, the report prepared with the EVM analysis presented both the delay in the implementation of the works, as well as their underestimation – resulting from the failure to overestimate the contractor's tender quotation. The analysis of the remaining works to be executed also diagnosed the underestimation of their value at the stage of preparing the tender quotation, and the lump-sum remuneration made it impossible for the contractor to claim additional payments for unforeseen works.

Figure 2 shows a report on the progress of works on the construction site using the earned value method, after the first month of the project: as of 31st March 2017. Higher than planned costs incurred (ACWP > BCWS) and lower than planned earned value (BCWP < BCWS) together with the recorded values of composite indexes (CPI, SPI < 1,000) signal a simultaneous delay and underestimation of works, additionally expressed as a variance from costs (CV < 0 00).

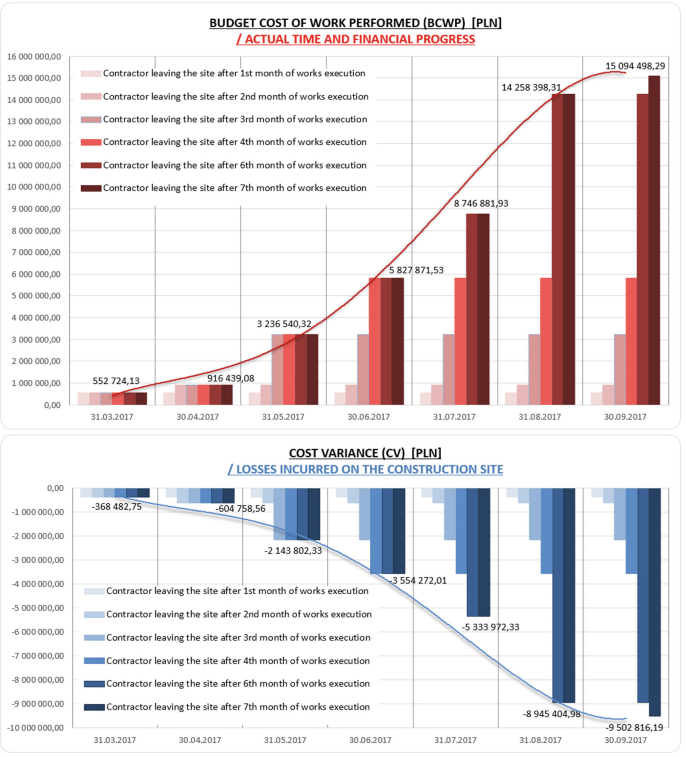

Fig. 3. Scenarios of monotonicity of the BCWP and CV for seven dates of the contractor leaving the site (interruption of construction works). Source: Own research and development, calculations in PLANISTA MAX.

Figure 3 shows the actual progress in terms of time and costs of the works carried out on the construction site, juxtaposed with the accompanying financial losses. The most common reason for contractors to terminate construction works contracts is the fact that the works are underestimated at the stage of their estimation, or the diagnosis of delays in execution, preventing their timely completion. The contractor's decision to leave the construction site must be preceded by an analysis of the necessary costs, generated by contractual penalties for failure to comply with the subject of the contract. Figure 3 summarizes the scenarios of monotonicity of the basic parameters of the EVM method – Budget Cost of Work Performed (BCWP) and cost variance (CV) – assuming further persistence of undesirable trends of delay and underestimation. These scenarios, in the number of seven, describe the course of further disruptions from the assumed schedule – in the case of continuation of works in the following months. The growing underestimation of the cost estimate of works, along with their delay, prompts an economic and financial analysis of the profitability of the entire project, compared with the pool of contractual penalties provided for in the construction contract.

Figure 4 shows the course of the schedule performance index (SPI) and the cost performance index (CPI) for seven monthly contractor exit scenarios determined by increasing production losses.

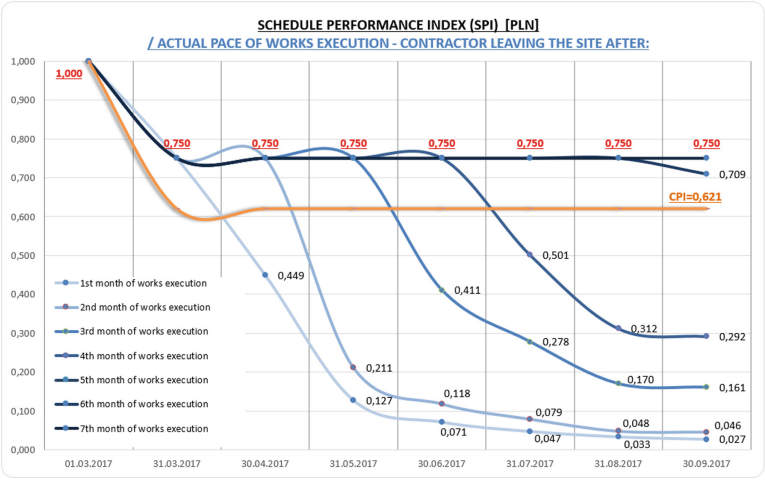

Fig. 4. Scenarios of monotonicity of the SPI for seven dates of the contractor leaving the site (interruption of construction works). Source: Own research and development, calculations in PLANISTA MAX.

The analysis of Figs. 2, 3, and 4 gives the answer how to use the EVM to determine the economic consequences for the contractor of works in the event of their interruption (leaving the construction site).

Along with the termination of works, the increase in the Budget Cost of Work Performed (BCWP), Actual Cost of Work Performed (ACWP) and Cost Variance (CV) is stopped – no production is carried out on the construction site. The value of Budget Cost of Work Scheduled (BCWS) continues to grow – according to the assumed schedule, to the final value of the project budget. The cost performance index (CPI) does not show changes in monotonicity, while the value of the schedule performance index (SPI) is constantly decreasing: depending on the adopted date of the contractor's leaving the construction site, to a level in the range of 2.7–70.9% – on the planned date completion of the project. The decrease in SPI value in individual scenarios illustrates the actual pace of works implementation, decreasing over time in relation to the overall planned pace. The aforementioned range of values on the planned date of completion of works shows what percentage of the scope of works could be completed in a timely manner in this project, depending on the moment of its termination. The monotonicity of the SPI, dictated by the following variants of the course of works, also shows the highest partial budgets of the project: in the third and sixth month of construction (distances between the graphs).

The results of the economic profitability analysis of the project are presented in Table 1. The forecast of the time and cost condition was prepared on the date of the planned completion of works: 30th September 2017 (EVM report).

The final values of the SPI [−], and the corresponding values expressed in money (SPI [PLN]), referring to the planned budget (SPI [30th September 2017] × BCWS [30th September 2017]) has been assigned to this date. In order to analyze the growing financial losses of construction, the increasing cost variances (CV), the value of ACWP and the value of the BCWP index, describing the measure of the actual progress of works in the venture were also compared.

The forecast for determining the underestimation and delays of works carried out according to the assumed schedule, together with contractual penalties, indicates that the analyzed project becomes unprofitable after the fourth month of works execution. During this period, the value of the losses incurred exceeds the costs of contractual penalties for failure to meet the subject of the contract (30/06/2017: $|CV| > K(ZU)$).).

The comparison of the schedule performance index SPI [PLN] expressed in amounts with the Budget Cost of Work Performed BCWP [PLN] in individual months of works shows slight differences of 1–2%. This configuration, in its absolute values, should, however, be compared with the Budget Cost of Work Scheduled (BCWS): then an increasing delay in the schedule becomes visible, which in turn leads to additional costs in the form of penalties for delayed completion of the entire project ($K(ZZ) = 20{,}106.85$ PLN/day of delay).

The description of increasing cost variances (CV) assumes a continuing trend of delays and underestimation of works carried out according to the schedule (no remedial actions on construction site). This parameter, in absolute value, represents the contractor's financial losses in the event of a decision to continue the works.

Table 1. Analysis of the profitability of the project in seven stages of its implementation EVM.

Date of EVM report: 30.09.2017	Contractor leaving the site (interruption of construction works) on						
	31.03.2017	30.04 2017	31.05 2017	30.06 2017	31.07 2017	31.08 2017	30.09 2017
SPI [−]	***0.027***	***0.046***	***0.161***	***0.292***	***0.435***	***0.709***	***0.750***
SPI [PLN]	542.885,00	924.915,19	3.237.203,17	5.871.200,78	8.746.480,61	14.255.758,05	15.080.138,98
CV [PLN]	−368.482,75	−604.758,56	−2.143.802,33	−3.554.272,01	−5.333.972,33	−8.945.404,98	−9.502.816,19
BCWP [PLN]	552.724,13	916.439,08	3.236.540,32	5.827.871,53	8.746.881,93	14.258.398,31	15.094.498,29
ACWP [PLN]	921.206,88	1.521.197,64	5.380.342,65	9.382.143,54	14.080.854,26	23.203.803,29	24.597.314,48
BCWS [PLN]	736.965,50	1.231.910,49	4.342.233.19	7.751.990,53	11.643.856,89	19.033.078,68	20.106.851,97
Breach of contract: **K(ZU) = 15% x 20.2016.851,97 = 3.016.027,80 PLN**							
Works delay: K(ZZ) = 0,1%/day x 20.106.851,97 = 20.106,85 PLN/day SPI = 0,750: delay 2,25 month (46 working days): **904.808,34 PLN**							

3 Conclusions from Research and Analyzes

The conducted economic analysis on the selected example of works execution, taking into account the effects of their interruption using the EVM method, gives important conclusions. The comparison of the results of the works progress report together with the costs of contractual penalties showed the unprofitability of the analyzed project after the fourth month of the works execution, in which the level of cost variances (CV, Fig. 3) exceeded the contractual amount for the contractor's failure to perform the contract.

The specified schedule performance index (SPI, Fig. 4) in the EVM shows the scenarios of stopping the works, depending on the moment of the decision to resign from their further performance. This index, presenting the actual pace of works implementation, also provides a forecast for future periods – with the final value of the project, describing the percentage of the project's budget implemented on time.

It is worth noting that a similar economic analysis of the works carried out could concern their profitability in the context of the processes to be performed, instead of monthly accounting periods. Then, the contractor's decision-making would describe the times of completion of individual activities in the schedule.

The presented earned value method (EVM), despite many disadvantages described in the literature, can be an effective tool for cost control and the actual efficiency of works. The presented approach may also be a solid contribution to increasing the decision-making efficiency of the contractor on the construction site.

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