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Research paper

Improving predictions of the Estimate at Completion using the classic Earned Value input

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Abstract: The article investigates the author's method of estimating the final cost of a construction investment. A list of proposed methods of calculating the value of the planned final cost of the EAC investment available in the world literature was used. The modification consisted in the first place in the verification and elimination of formulas that do not match the use in construction projects and the combination of formulas resulting in the same result. The study was aimed at enabling the right choice of the method of estimating the final cost of construction investments and determining the accuracy of this estimate. It should be emphasized that the analyzed investments were annexed many times during their implementation. On the basis of the obtained results of research carried out on real construction investments, it was found that 3 methods best predict the final cost of the investment. Finally, improvements were introduced, which were analyzed, the final effect of the article is a proposal of an original, universal formula, which in each of the analyzed construction investments, regardless of the trends, deviations from the cost at the time of the inspection, forecasts the most accurate result, consistent with reality. The conducted research gives the possibility of more effective financial management of a construction investment using the corrected EAC formula in EVM method.

Keywords: investment management, final cost forecast, building disturbances, EVM method, EAC formula

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1. Introduction

One of the main advantages of the Earned Value Management (EVM) method is the ability to estimate the final cost of the project [1,2]. As A. Rak and D. Przywara very aptly describe in their article [3], the Earned Value Method (EVM) is recognized as an advanced method of controlling production ventures, which provides working results in the form of quantitative and qualitative indicators. The purpose of developing the EVM method was to link the material progress of works and the costs incurred-against the background of planned values. This tool, "introduced" to construction sites, has been effectively implemented and disseminated. Managers managing complex construction contracts use key words to assess the progress of their schedules, fully describing planned and actual turnover, budget, and timeliness of implementation [4,5].

EVM consists of the following three basic elements. All the three elements are captured on a regular basis as of a reporting date.

(1) BCWS (Budgeted Cost of Work Scheduled) is also referred to as Planned value PV – the total cost of the work scheduled/planned as of a reporting date:

$$\text{PV or BCWS} = \text{Hourly Rate} \times \text{Total Hours Planned or Scheduled} \tag{1.1}$$

– hourly perform the rate at which effort will be valued.

(2) BCWP (Budgeted Cost of Work Performed) performed referred to as Earned value EV – the total cost of the work completed/performed as of a reporting date:

$$\text{EV or BCWP} = \text{Baselined Cost} \times \text{\% Complete Actual} \tag{1.2}$$

- % Complete Actual – The percentage of work which was actually completed by the Reporting Date:
  % Completed Actual = AC/EAC
- % Completed Planned – The percentage of work which was planned to be completed by the Reporting Date: % Completed Planned = PV/BAC

(3) ACWP (Actual Cost of Work Performed) is also referred to as Actual cost AC – the total cost taken to complete the work as of a reporting date:

$$\text{AC or ACWP} = \text{Hourly Rate} \times \text{Total Hours Spent} \tag{1.3}$$

The BCWS, BCWP and ACWP values are the basis for determining the indicators of the Earned Value Method divided into two groups:

(I) indices for the progress of construction works – values that allow to determine the current pace of construction works and the current financial balance of construction in relation to completed tasks. In order to precisely determine their advancement, the EVM method provides for the calculation of the following indices:

$$\text{CV (Cost Variance): CV} = \text{BCWP} - \text{ACWP} \tag{1.4}$$

– the CV illustrates the current deviation of construction costs from the plan. A negative value indicates that the budget has been exceeded by the date of the report.

$$\text{SV (Scheduled Variance): SV} = \text{BCWP} - \text{BCWS} \tag{1.5}$$

A negative value indicates a delay in planned costs of construction works, including individual construction works.

$$\text{CPI (Cost Performance Index): CPI} = \text{BCWP}/\text{ACWP} \tag{1.6}$$

If the CPI index is less than one, this indicates that the budget has been exceeded.

$$\text{SPI (Schedule Performance Index): SPI} = \text{BCWP}/\text{BCWS} \tag{1.7}$$

If the SPI index is less than one, this indicates a delay in construction works on a given investment.

(II) indices for forecasting future costs of construction works and the pace of their implementation
EAC (Estimated Cost At Completion) – the estimated cost of the project at the end of the project – Table 1

$$\text{ETTC (Estimated Time At Completion): ETTC} = \text{ATE} + \frac{\text{OD} - (\text{ATE} \times \text{SPI})}{\text{SPI}} \tag{1.8}$$

ATE – time from commencement of construction works to the date of the report,
OD – planned total duration of construction works,
SPI – Schedule Performance Index.

The EVM method is one of performance-based project management methods and is an effective tool for controlling projects in terms of costs, time, and scope of works done [6].

The concept of controlling construction investments is based on the EVM method, however, after carrying out a number of studies aimed at improving the EVM method for controlling construction investments, it was noticed that the formulas used to estimate the final cost of the investment should be corrected. One should ask oneself which of the proposed methods of estimating the final cost are applicable in the implementation of construction projects and how accurate the forecast is made with their help.

In order to conduct original research on the methods of estimating the final cost of a construction investment, a list of proposed methods available in the world literature for calculating the value of the planned final cost of the EAC investment was used. The modification consisted in the verification and elimination of formulas that do not match the use in construction projects and the combination of formulas resulting in the same result, which is included in the Table 1, by assigning several researchers in the "author" column.

Table 1. List of analyzed methods used to calculate the estimated final costof construction investments

Author	Formula	Symbol
A. Webb1995 [7] /T.Wilkens1999 [8]	$EAC = ACWP + \dfrac{(BAC - BCWP)}{CPI}$	EAC_1
A. Webb1995 [7]	$EAC = ACWP + \dfrac{(BAC - BCWP)}{0.5 \cdot CPI + 0.5 \cdot SPI}$	EAC_2
A. Webb1995 [7]	$EAC = ACWP + \dfrac{(BAC - BCWP)}{CPI \cdot SPI}$	EAC_3
K. Heinze1996 [9] / F.Anbari2003 [10]	$EAC = \dfrac{BAC}{CPI \cdot SPI}$	EAC_4
Department of Energy, USA2003 [11]	$EAC = (AC/EV) \times BAC$	EAC_6
Department of Energy, USA2003 [11]	$EAC = AC/EV \times$ [*Work Completed and in Progress*] + [*Cost of work not yet begun*]	EAC_7
Department of Energy, USA2003 [11]	$EAC = AC + [1/CPI(BAC - EV)]$	EAC_8
F. Anbari 2003 [10]	$EAC = BAC - CV$	EAC_9
K. Athey 2007 [12]	$EAC = \text{Actual Cost} + \dfrac{\textit{Remaining Budget}}{CPI \cdot SPI}$	EAC_{10}
K. Athey 2007 [12]	$EAC = \text{Actual Cost} + \dfrac{\textit{Remaining Budget}}{CPI}$	EAC_5

where:
EAC (Estimated Cost At Completion) – the estimated cost of the project at the end of the project;
ACWP (Actual Cost of Work Performed) = AC (Actual cost) – the total cost taken to complete the work as of a reporting date;
BCWP (Budgeted Cost of Work Performed) = EV (Earned value) – the total cost of the work completed/performed as of a reporting date;
BCWS (Budgeted Cost of Work Scheduled) = PV (Planned value) – the total cost of the work scheduled/planned as of a reporting date;
CV (Cost Variance) – the CV illustrates the current deviation of construction costs from the plan. A negative value indicates that the budget has been exceeded by the date of the report;
SV (Scheduled Variance) – a negative value indicates a delay in planned costs of construction works, including individual construction works;
CPI (Cost Performance Index) – If the CPI index is less than one, this indicates that the budget has been exceeded.
SPI (Schedule Performance Index) – If the SPI index is less than one, this indicates a delay in construction works on a given investment.
BAC (Budget at Completion) is the total budget allocated to the project.
Work Completed and in Progress – completed and in-progress works include all works completed by the date of the inspection and those works that were at least partially completed on the day of the inspection - then the part of the works already completed is taken into account.
Cost of work not yet begun – this is the cost of planned works that have not yet been completed or started.
Remaining Budget – this is a budget that has not yet been spent. It is intended for works planned or not yet completed.

2. Research description

The charts (Figs. 1–3) show the estimated final cost determined by the individual formulas in subsequent periods of the implementation of the analyzed construction investments.

Investment no. 1 – construction of a residential block no. 1

Description of the investment 1: Building with a basement and three floors above ground with an unusable attic. The scope of construction also includes the construction of playgrounds, a road, a maneuvering area and a sidewalk based on the detailed design prepared by the Design Studio and the scope of works specified in the cost estimates. The construction project consists of 5 sectors: construction, sanitary, electrical, telecommunications and road; volume: 7200 m^3; usable area: 2900 m^2

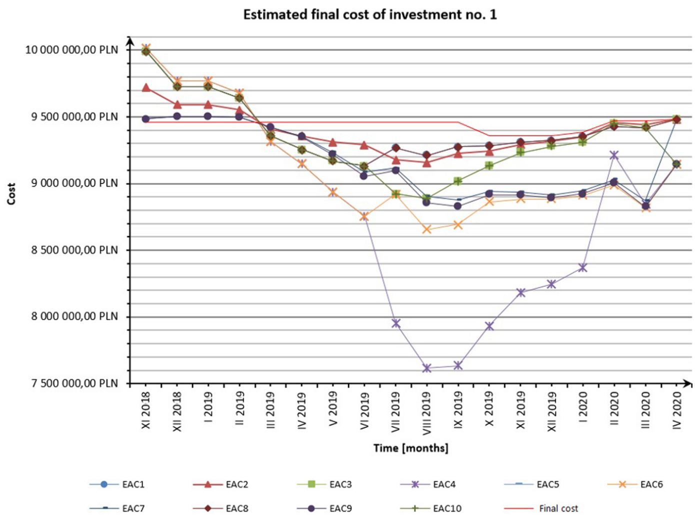


Fig. 1. Chart of estimating the final EAC cost of investment no. 1 using the available formulas

Investment no. 2 – construction of residential building no. 2

Description of the investment 2: Construction of a residential building in the construction, electrical, sanitary and telecommunications industries. The scope of construction also includes demolition of the garage and construction of a fire road; volume: 6500 m^3; usable area: 2490 m^2

Investment no. 3 – comprehensive thermal modernization of residential buildings

Description of the investment 3: The subject of the order was the performance of design and construction works related to the comprehensive thermal modernization of facilities based on the guidelines contained in the developed energy audits of buildings, documentation and the functional and utility program.

These were four residential buildings, each with a volume of over 8000 m^3 and a usable area of over 3000 m^2. Each facility had 4 above-ground floors.

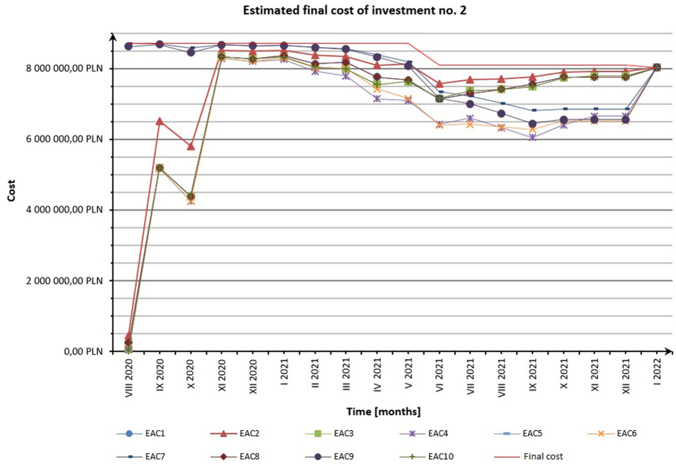


Fig. 2. Chart of estimating the final EAC cost of investment no. 2 using the available formulas

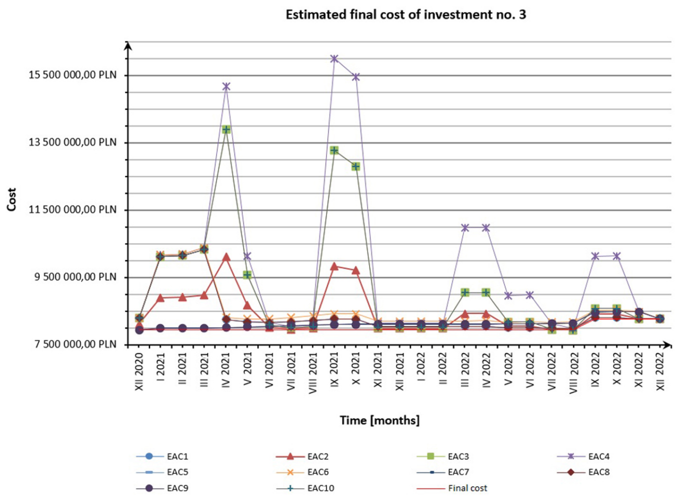


Fig. 3. Chart of estimating the final EAC cost of investment no. 3 using the available formulas

The study was aimed at enabling the right choice of the formulas of estimating the final cost of construction investments and determining the accuracy of this estimate.

In each of the analyzed investments, the use of formulas with the numbers: EAC4, EAC6, EAC7, EAC9, EAC10 resulted in the estimated final cost with the greatest error. After eliminating formulas with extreme values, formulas were adopted for detailed research with numbers: EAC1, EAC2, EAC3, EAC8.

The selected 5 formulas were analyzed in terms of the possibility of accurate estimation of the final cost of construction (Figs. 4–6), regardless of the emerging trends and the impact of random factors during the investment. It should be emphasized that the analyzed investments were annexed many times during their implementation.

Investment no. 1 – construction of a residential block no. 1

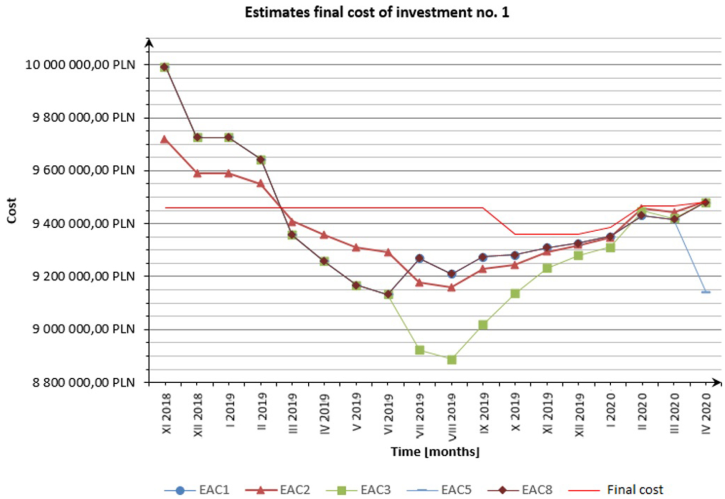


Fig. 4. Chart of estimating the final EAC cost of investment no. 1 using selected formulas

Investment no. 1 was implemented in the period from November 2018 to April 2020, i.e. 18 months. After 4–5 months (22–28% progress), the cost forecast graphs intersect with the graph of the final cost, the forecast becomes slightly underestimated, it is only after 12 months that the graph finally begins to stabilize and allows an accurate forecast of the final cost of the project at 60–70% of its completion.

Investment no. 2 – construction of a residential building no. 2

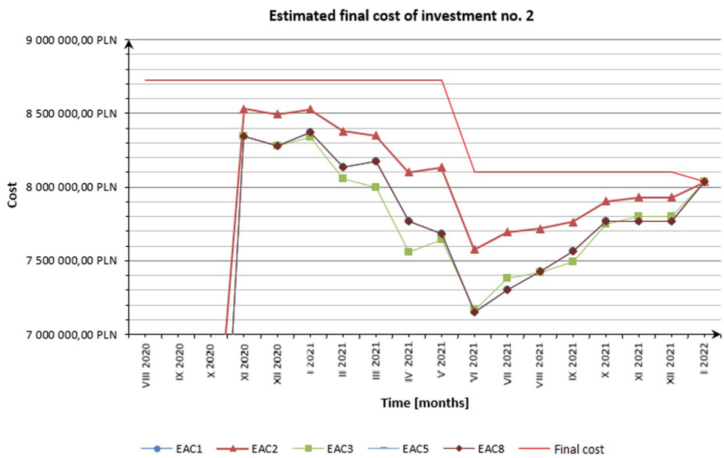


Fig. 5. Chart of estimating the final EAC cost of investment no. 2 using selected formulas (Explanation: Presenting the minimum value for EAC1, EAC2, EAC3, EAC5, EAC8 on the chart was not important because the author of the study focused on examining the smallest possible deviations from the final cost. As you can see, the final cost was set at the beginning as a base budget of several million PLN, while the EAC1, EAC2, EAC3, EAC5, EAC8 values started at 0, which was not tested)

Investment no. 2 was implemented in the period from August 2020 to January 2022, i.e. 18 months. After 4 months, the graphs begin to take shape in line with the actual cost, but slightly lower (advancement: 22–23%). The graphs begin to stabilize in the 15th month and it enables an accurate forecast of the final cost of the project at more than 80% of its completion.

Investment no. 3 – comprehensive thermal modernization of residential buildings

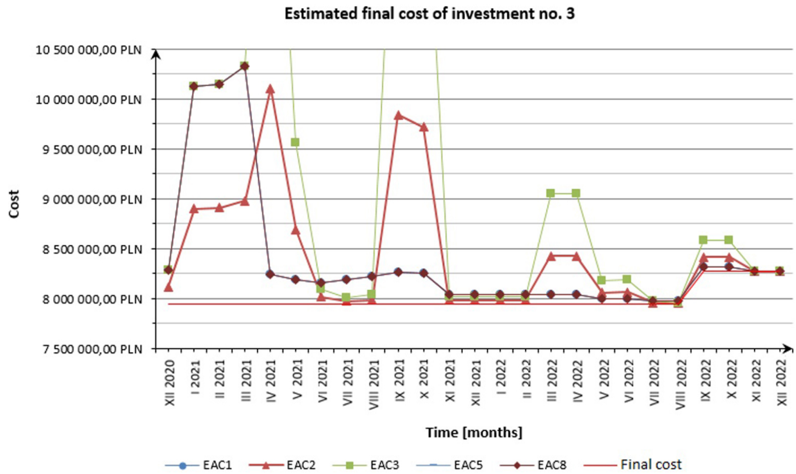


Fig. 6. Chart of estimating the final EAC cost of investment no. 3 using selected formulas (Explanation: Presenting the maximum EAC3 value on the chart was not important because the author of the study focused on examining the smallest possible deviations from the final cost, so these maximum EAC3 values were rejected. Moreover, it would distort the image on the chart for important issues that were examined, i.e. checking the compliance of the EAC1, EAC2 and EAC3 methods with the final cost, which is 8–8.5 million PLN for chart 6)

Investment no. 3 was implemented in the period from December 2020 to December 2022, i.e. 25 months. After 5 months, some of the charts begin to stabilize, the same applies to the subsequent charts after 7 months of the investment. After 12 months, all charts are stabilized. This makes it possible to forecast the final cost of the project with an advancement of 20-48%. The exception is the EAC3 formula, the deviations of which are visible until the end of the investment.

On the basis of the obtained test results, it was found that the formulas proposed by A. Webb in 1995, i.e. EAC1, EAC2, EAC3 still belong to the best estimates of the final investment cost. Forecasts of similar quality can be obtained using the Department of Energy, USA/Anbari 2003 (EAC8) and Athey 2007 (EAC5) formulas. However, they are characterized by a slightly underestimated final cost at 20–30% of the investment advancement [13–15].

It should be noted, however, that the impact of disturbances factors is still not taken into account here, which in the case of significant fortuitous events may result in forecast errors. Risk analysis of construction projects is possible on the basis of data collected for the traditional EVM method [16–18].

Based on the results of research conducted on real construction investments in the above chapter, it was found that the formulas marked in the research as EAC1, EAC2 and EAC3 best predict the final cost of the investment.

The formulas of forecasting the final cost of a construction investment presented above differ only in the value of the denominator appearing in the second part of each of the formulas. The denominator is the cost performance ratio or the sum or product of this ratio and the schedule performance ratio.

Therefore, it is necessary to consider how both of these indicators affect the correctness of the forecast of the final cost of the investment, regardless of the trends and deviations of the investment at the time of the inspection.

The selected three formulas allow you to correct the components used in them:

1. The denominator is only CPI index

$$\mathrm{EAC1} = \mathrm{ACWP} + \frac{(\mathrm{BAC} - \mathrm{BCWP})}{\mathrm{CPI}} \tag{2.1}$$

2. The denominator includes both CPI index and SPI index as the sum of these two indicators

$$\mathrm{EAC2} = \mathrm{ACWP} + \frac{(\mathrm{BAC} - \mathrm{BCWP})}{0.5 \cdot \mathrm{CPI} + 0.5 \cdot \mathrm{SPI}} \tag{2.2}$$

3. The denominator includes both the CPI index and the SPI index as the product of of these two indicators

$$\mathrm{EAC3} = \mathrm{ACWP} + \frac{(\mathrm{BAC} - \mathrm{BCWP})}{\mathrm{CPI} \cdot \mathrm{SPI}} \tag{2.3}$$

First of all, one should ask oneself what kind of forecast would be provided by a formula containing only the value of the SPI index in the denominator.

The above problem was analyzed using three formulas that best predict the final cost of the investment.

The correction applied in each of the formulas consisted in changing the denominator in the formula and making it dependent only on the performance indicator of the execution of the schedule. It is worth remembering that the SPI also depends on costs (formula (1.7)).

The analysis consisted in comparing the following formulas: EAC1, EAC2, EAC3 with the EAC formula after the change.

1. The EAC1 formula has only the CPI indicator

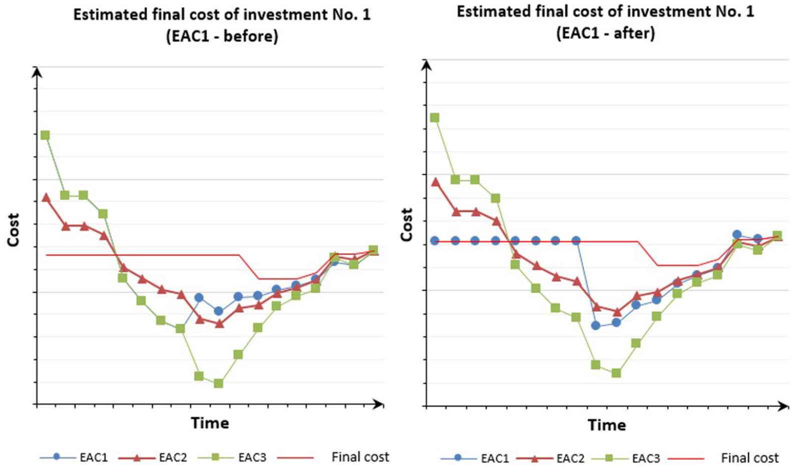
Below is the formula before and after the correction:

$$\mathrm{EAC1}_{(\mathrm{before})} = \mathrm{ACWP} + \frac{(\mathrm{BAC} - \mathrm{BCWP})}{\mathrm{CPI}} \tag{2.4}$$

$$\mathrm{EAC1}_{(\mathrm{after})} = \mathrm{ACWP} + \frac{(\mathrm{BAC} - \mathrm{BCWP})}{\mathrm{SPI}} \tag{2.5}$$

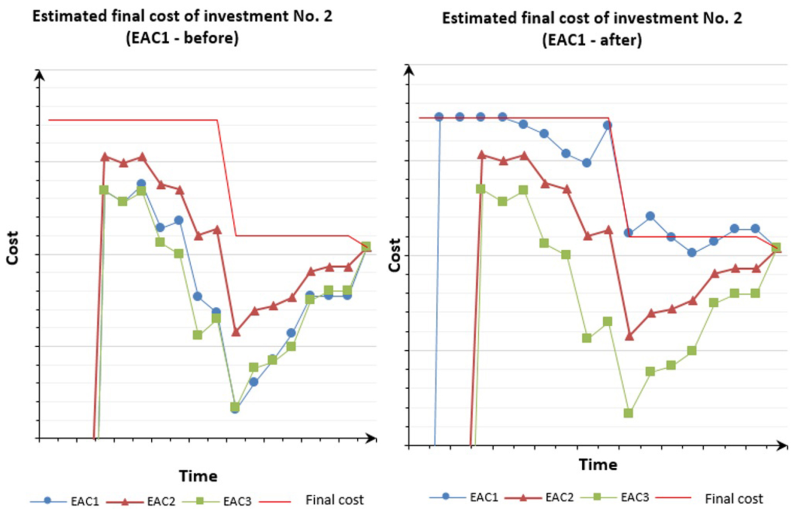
The symbols in the above formulas are explained under Table 1 in Chapter 1 of this article.

The final cost forecast charts are shown on the next page in each of the three analyzed construction investments, showing the differences in the EAC1 formula without and after the change in the formula (Figs. 7–9).



(a) (b)

Fig. 7. Graphs for estimating the final EAC cost of investment no. 1 using selected formulas showing the differences in the EAC1 formula before (a) and after (b) the change



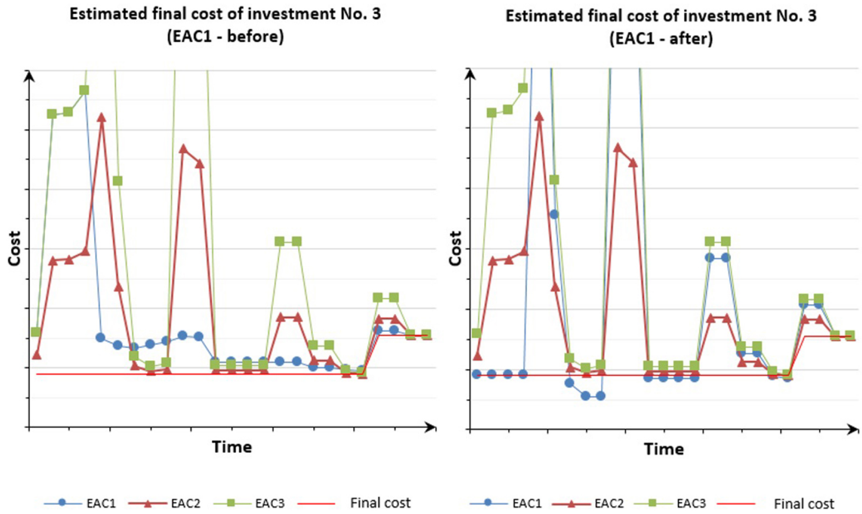
(a) (b)

Fig. 8. Graphs for estimating the final EAC cost of investment no. 2 using selected formulas showing the differences in the EAC1 formula before (a) and after (b) the change

2. The EAC2 formula has both CPI and SPI as a sum of these indicators
Below is the formula before and after the correction:

$$\text{EAC2}_{(\text{before})} = \text{ACWP} + \frac{(\text{BAC} - \text{BCWP})}{0.5 \cdot \text{CPI} + 0.5 \cdot \text{SPI}} \tag{2.6}$$

$$\text{EAC2}_{(\text{after})} = \text{ACWP} + \frac{(\text{BAC} - \text{BCWP})}{\text{SPI}} \tag{2.7}$$

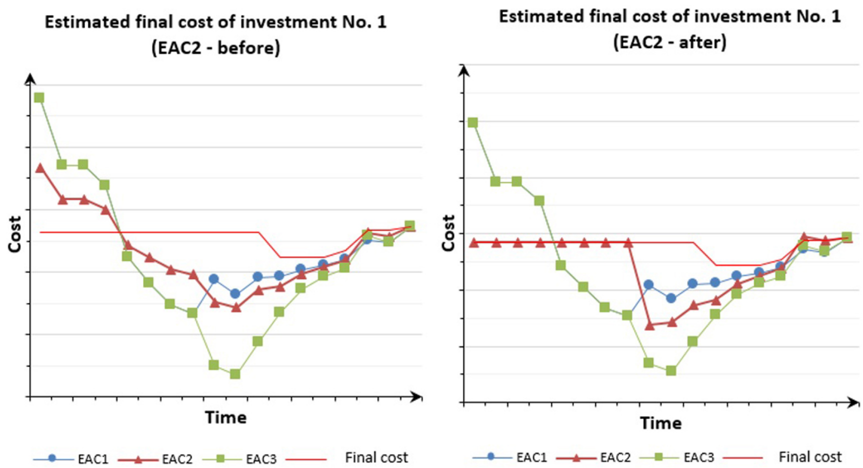


(a) (b)

Fig. 9. Graphs for estimating the final EAC cost of investment no. 3 using selected formulas showing the differences in the EAC1 formula before (a) and after (b) the change

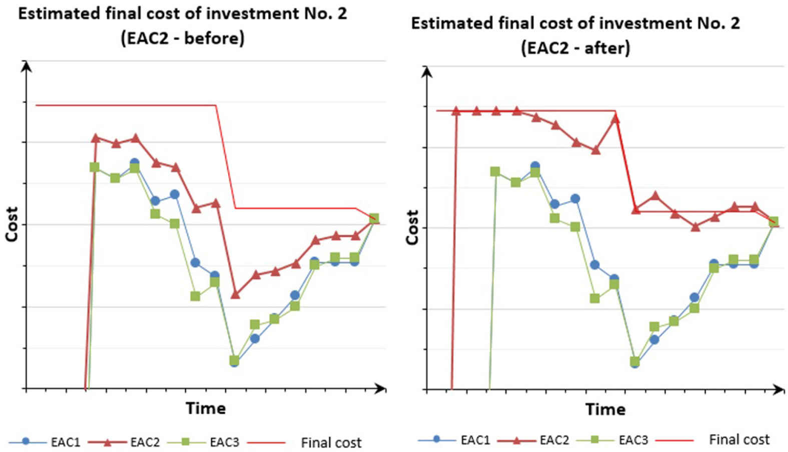
The symbols in the above formulas are explained under Table 1 in Chapter 1 of this article.

The final cost forecast charts are shown on the next page in each of the three analyzed construction investments, showing the differences in the EAC2 formula without change and after the applied change in the formula (Figs. 10–12).



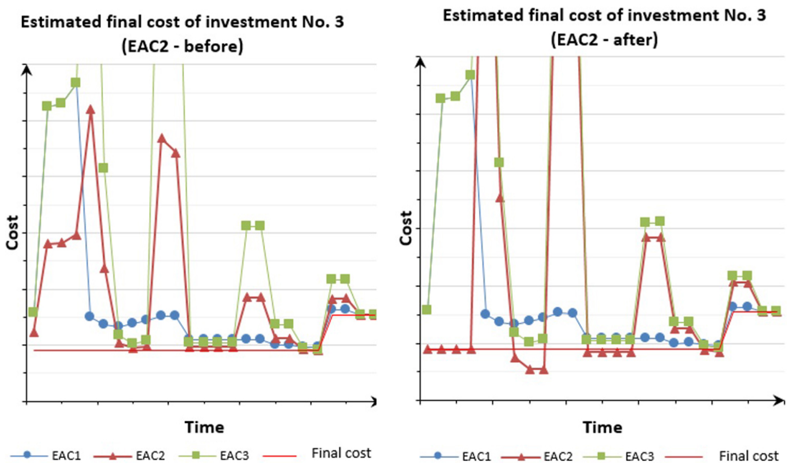
(a) (b)

Fig. 10. Graphs for estimating the final EAC cost of investment no. 1 using selected formulas showing the differences in the EAC2 formula before (a) and after (b) the change



(a) (b)

Fig. 11. Graphs for estimating the final EAC cost of investment no. 2 using selected formulas showing the differences in the EAC2 formula before (a) and after (b) the change



(a) (b)

Fig. 12. Graphs for estimating the final EAC cost of investment no. 3 using selected formulas showing the differences in the EAC2 formula before (a) and after (b) the change

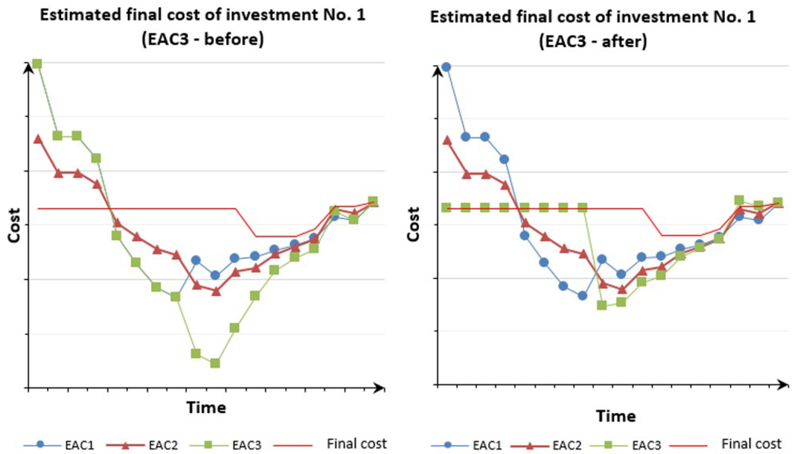
3. The EAC3 formula has both CPI and SPI indices as a product of these indices Below is the formula before and after the correction:

$$\text{EAC3}_{(\text{before})} = \text{ACWP} + \frac{(\text{BAC} - \text{BCWP})}{\text{CPI} \cdot \text{SPI}} \tag{2.8}$$

$$\text{EAC3}_{(\text{after})} = \text{ACWP} + \frac{(\text{BAC} - \text{BCWP})}{\text{SPI}} \tag{2.9}$$

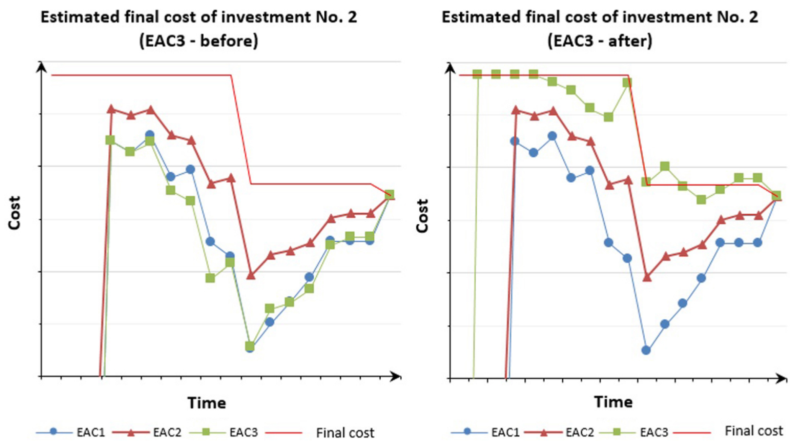
The symbols in the above formulas are explained under Table 1 in Chapter 1 of this article.

The final cost forecast charts are shown on the next page in each of the three analyzed construction investments, showing the differences in the EAC3 formula without change and after the applied change in the formula (Figs. 13–15).



(a) (b)

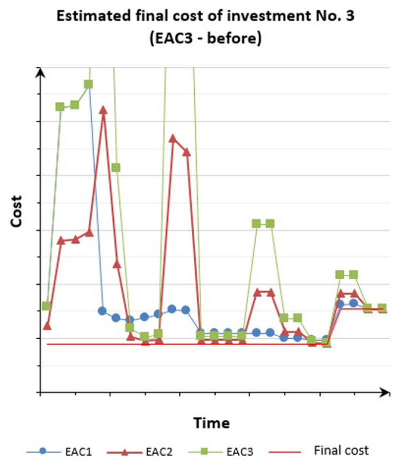
Fig. 13. Graphs for estimating the final EAC cost of investment no. 1 using selected formulas showing the differences in the EAC3 formula before (a) and after (b) the change



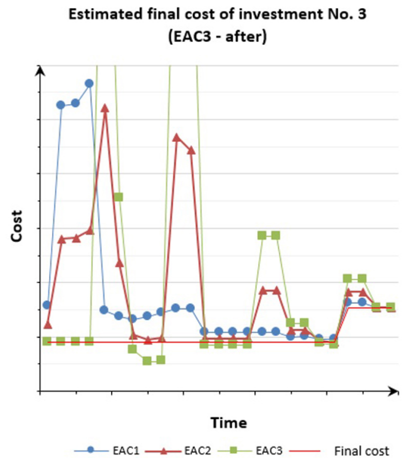
(a) (b)

Fig. 14. Graphs for estimating the final EAC cost of investment no. 2 using selected formulas showing the differences in the EAC3 formula before (a) and after (b) the change

After the research, it was noticed that both in investment no. 1 and investment no. 2, the final cost forecast determined using the changed EAC formula gives better results – more close to reality. However, in the case of investment no. 3, the behavior of the CPI index in the formula



(a)



(b)

Fig. 15. Graphs for estimating the final EAC cost of investment no. 3 using selected formulas showing the differences in the EAC3 formula before (a) and after (b) the change

allows to obtain results more similar to the real ones. The universal formula should include both the CPI and and SPI. In the proposed solutions, the denominator of the formula includes:

- sum of CPI and SPI indicators,
- product of CPI and SPI indicators.

3. Results

The analysis clearly shows that the sum of the indicators gives a better forecast of the final cost of the investment than their product, regardless of the construction trend at the time of the inspection. This shows that a smaller value of the denominator has a better effect on the correctness of the forecast.

In view of the above, we should therefore look at the results of the research if we insert an even smaller value in the denominator of the formula, i.e. the square root of the sum of the CPI and SPI indices.

The proposed formula for estimating the final cost of the investment:

$$\text{EAC}_{(\text{proposed})} = \text{ACWP} + \frac{(\text{BAC} - \text{BCWP})}{\sqrt{0.5 \cdot \text{CPI} + 0.5 \cdot \text{SPI}}} \tag{3.1}$$

The symbols in the above formulas are explained under Table 1 in Chapter 1 of this article.

The graphs of the final cost forecast are presented below in each of the three analyzed construction investments, showing the differences in the proposed EAC formula and in the best currently available formulas (Figs. 16–18).

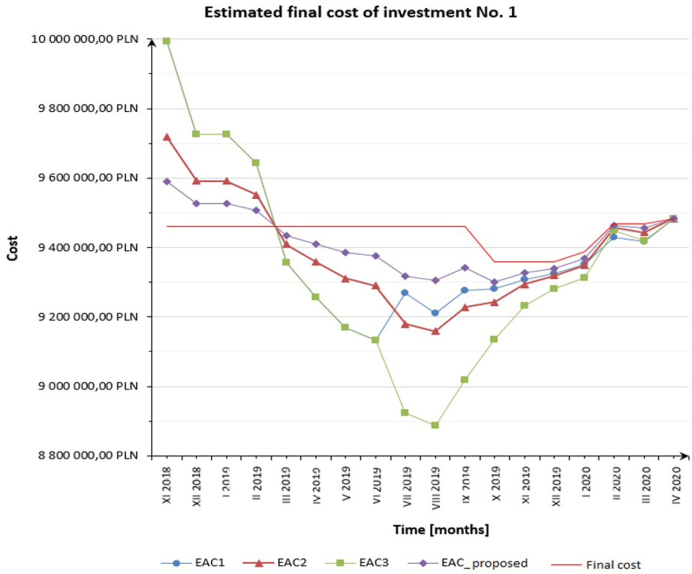


Fig. 16. Graphs for estimating the final cost of investment no. 1 using the applicable EAC1, EAC2, EAC3 formulas and the proposed EAC formula

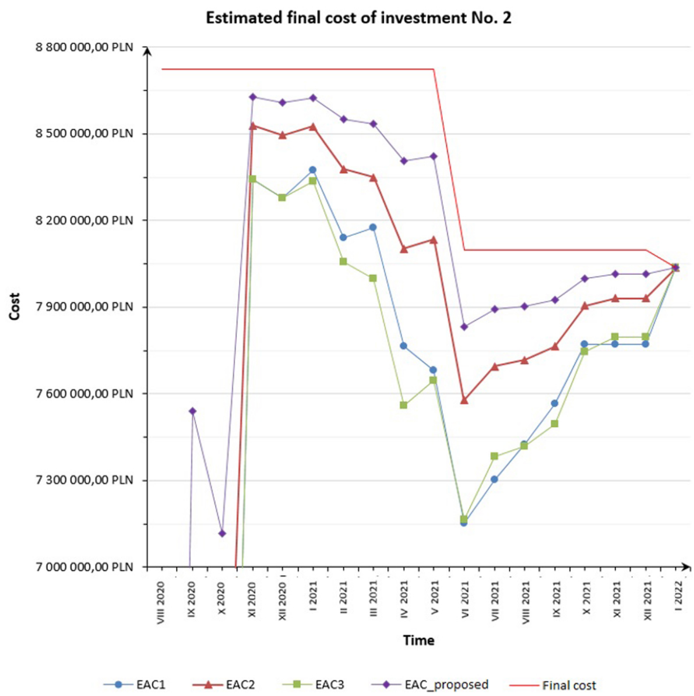


Fig. 17. Fig. 17. Graphs for estimating the final cost of investment no. 2 using the applicable EAC1, EAC2, EAC3 formulas and the proposed EAC formula

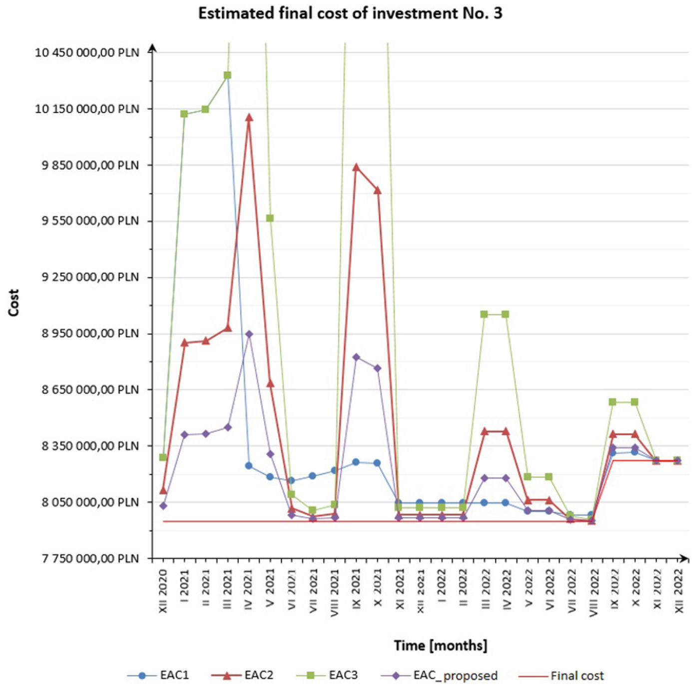


Fig. 18. Graphs for estimating the final cost of investment no. 3 using the applicable EAC1, EAC2, EAC3 formulas and the proposed EAC formula

After detailed research, it was clearly stated that the proposed proprietary formula:

$$\mathrm{EAC}_{(\mathrm{proposed})} = \mathrm{ACWP} + \frac{(\mathrm{BAC} - \mathrm{BCWP})}{\sqrt{0.5 \cdot \mathrm{CPI} + 0.5 \cdot \mathrm{SPI}}} \tag{3.2}$$

The symbols in the above formulas are explained under Table 1 in Chapter 1 of this article.

in each of the analyzed construction investments, regardless of trends, deviations from the cost or schedule at the time of the inspection, it forecasts the most accurate result, consistent with reality.

4. Conclusions

The proposed formula (3.2), taking into account both the impact of the CPI cost performance index and the SPI schedule performance index, as well as reducing the value of the denominator by using the square root, makes it universal. The applied multiplier of 50% provides for a situation in which, with the values of CPI = 1 and SPI = 1, the formula is not dependent on the denominator of the fraction. It also takes into account the possibility of a variant where the investment is carried out in accordance with the base plan, i.e. with the material and financial construction schedule. The conducted research gives the possibility of more effective financial management of a construction investment using the corrected EAC formulas in the EVM method. The method does not change the construction management process, however, it ensures realistic consideration of the influence of random factors on the course and results of individual works and the entire project [19–21]. It allows for a better estimate of the total costs of works and, according to the established conditions of implementation, to correct the construction plan. The EVM method [22–24] presented and used in this way can become the basis for conducting accurate analyzes and control of ongoing construction investments, being fully aware of the cost changes taking place in them, as well as knowing the final cost of the construction investment [25–27].

5. Discussion

Researchers' approach to the classic EVM method and their proposals regarding the formula itself for estimating the final cost of an EAC investment are described in detail in Chapter 1 of this article, and Table 1 contains the names of all researchers who contributed to the development of this method in the investment management process.

However, current research on proposed changes and extensions to the EVM method concerns the possibility of adapting it to construction investments as well as to risk conditions in which the investment is exposed to unpredictable random factors and construction disturbances:

1. Przywara D. and Rak A. in their article [3] attempt to analyze the emerging time and cost deviations using proprietary time variances from the schedule (T/S) and variances from planned costs (T/C) monitoring, based on simple indicators of the earned value method (EVM).
2. Abdullah M. Alsugair *et al.* in their article [28] develop a model to predict final construction contract duration (FCCD) in the early stages based on parameters characterized as few and shared for any contract: contract cost, contract duration and sector.
3. The aim of the research conducted by Cho Daegu *et al.* [29] was propose a data processing algorithm for integrated cost-schedule data management employing big data technology. It is designed to resolve the main obstacle to the practicality of existing methods by providing integrity and flexibility in integrating cost-schedule data and reducing time on building and changing databases.

In the construction industry, however, experts' experience and intuition are still key determinants in decision-making, cost and schedule controls, which are closely connected, are decisive in the success of construction project execution. While a vast body of research has developed methodologies for cost-schedule integration over 50 years, there is no method used in practice; it remains a significant challenge in the construction industry [29].

Therefore, the aim of this article, as well as other currently conducted research in the field of construction investment management and control methods [30–32], is to create tools friendly to construction managers, which can be easily used and draw accurate conclusions allowing the investment to be completed within the planned time and cost, despite occurring building disturbances.

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Udoskonalanie oszacowania ostatecznych kosztów przy użyciu metody wartości wypracowanej

Słowa kluczowe: zarządzanie inwestycją, prognoza kosztów końcowych, zakłócenia budowlane, metoda EVM, formuła EAC

Streszczenie:

W artykule zbadano autorską metodę szacowania ostatecznego kosztu końcowego inwestycji budowlanej. Wykorzystano listę proponowanych metod obliczania wartości ostatecznego kosztu końcowego inwestycji EAC dostępną w literaturze światowej. Modyfikacja polegała przede wszystkim na weryfikacji i eliminacji formułnieprzystających do zastosowania w inwestycjach budowlanych oraz łączeniu formuł dającym ten sam wynik. Celem badania było umożliwienie wł aściwego wyboru metody szacowania ostatecznego kosztu inwestycji budowlanych oraz określenie trafności tego oszacowania. Należy podkreślić, że analizowane inwestycje były wielokrotnie aneksowane w trakcie ich realizacji. Na podstawie uzyskanych wyników badań przeprowadzonych na rzeczywistych inwestycjach budowlanych stwierdzono, że 3 metody najlepiej przewidują ostateczny koszt końcowy inwestycji. Ostatecznie wprowadzono ulepszenia, które poddano analizie, efektem końcowym artykułu jest propozycja oryginalnej, uniwersalnej formuły, która w każdej z analizowanych inwestycji budowlanych, niezależnie od trendów, odchyleń od kosztów w momencie kontroli, prognozuje najdokładniejszy wynik, zgodny z rzeczywistością. Przeprowadzone badania dają możliwość efektywniejszego zarządzania finansami inwestycji budowlanej przy wykorzystaniu skorygowanej formuły EAC w metodzie EVM.

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