Article

Not peer-reviewed version

The Course of Cost Variability During the Execution of Sustainable Construction Projects

Jarosław Konior *

Posted Date: 14 April 2026

doi: 10.20944/preprints202604.0954.v1

Keywords: sustainable construction project; course of cost variability; S-curve; earned value method

 doi:10.20944/preprints202604.0954.v1

Article

The Course of Cost Variability During the Execution of Sustainable Construction Projects

Jarosław Konior

Department of Building Engineering, Faculty of Civil Engineering, Wroclaw University of Science and Technology, 50-370 Wrocław, Poland; jaroslaw.konior@pwr.edu.pl

Abstract

The article presents the results of research on the course of variability of planned and actual cost during the implementation of sustainable construction projects. The correlation of cost-time parameters in implementation in a group of 41 investment tasks, classified into five typologically homogeneous construction sectors in Poland, completed in the years 2006 – 2025, was examined. All of these enterprises have been designed and carried out within sustainable requirements and all fulfilled either platinum or gold LEED certification. The logistic centres have been executed in line with BREEAM certification. The course of cost volatility and the functions of the cost trend during the implementation of sustainable investment tasks were determined. Proven managerial tools were used, well described scientifically – the S-curve and the EVM method. The result of the research achievement is to confirm the correctness of the main thesis of the research: cost and time of implementation are not completely interdependent parameters and show great variability during the implementation of typologically diverse, although uniformly balanced construction projects. Finally – as regard sustainability – there is no correlation between sustainable design with execution and cost course of construction projects. Deep analysis of construction costs variability of sustainable diverse enterprises led to the main conclusion: design and construction of sustainable projects in accordance to LEED or BREEAM certification do not guarantee execution projects in line with their planned cost, no matter what sector the project belongs to.

Keywords: sustainable construction project; course of cost variability; S-curve; earned value method

---

1. Introduction

Cost and time are widely recognized as the two most important parameters for assessing the progress of construction projects. Together, they create a pair of metrics that enable the analysis of efficiency, effectiveness and compliance of the project with the assumed investment goals. Measuring these parameters not only allows you to track the progress of the work, but also allows you to detect deviations from the plan at an early stage, such as budget overruns or delays in the schedule, which can jeopardize the success of the construction project.

In the context of construction works, cost is a reflection of the financial outlay of resources, such as materials, equipment or labour, that are necessary to complete certain tasks. Time, in turn, determines the deadlines by which these tasks should be performed, according to the schedule set in the project plan. The concept of time is identical with the deadline for implementation. So it seems that both of these parameters are related to each other, and changing one of them should affect the change of the other parameter.

The interdependence of cost and time in the implementation of construction projects is a key aspect of the management of construction projects, especially those that have been carried out in a sustainable manner. The course of cost and time variability of sustainable investment tasks most fully reflects the interdependence of these two parameters in project management.

 doi:10.20944/preprints202604.0954.v1

According to the triad, project management, including construction projects, is related to time, cost and quality [1]. Changing one of these elements affects the others. For example, shortening the lead time, i.e. accelerating the construction completion date, may result in increased costs resulting from an increase in the number of work brigades. Accelerating construction work may involve the need to hire more employees or order overtime, which increases costs. On the other hand, improper cost estimation at the stage of planning a construction project may lead to delays in its implementation. Therefore, proper planning and coordination of work are crucial to minimize costs related to, for example, delays.

2. Literature Survey

The aim of this literature review was to systematize knowledge about the interdependence of cost and time in various construction projects. It is a synthetic approach to issues directly or indirectly related to the study of the interdependence of the aforementioned features. The literature survey indicated insufficient recognition of the interdependence of cost and deadline exceeding. In particular, there was a lack of research based on empirical research material. The need for continuation of the research was also indicated by the observed large discrepancy in the results obtained. Thirteen authors pointed to a significant correlation between cost and time. The conclusions of the researchers [2], supported by empirical research, indicated that both parameters did not show features that could unambiguously indicate this convergence.

Many studies have been conducted to analyse the above elements, i.e. the cost, time of construction projects, as well as their exceedances and interdependencies [3–10]. The authors write about the strong correlation between delaying the implementation time and exceeding the cost [11]. Researchers came to similar conclusions in articles [6–8] and [12], who saw the reason for delays in projects as exceeding their cost and vice versa.

Studies confirm that the time and cost of construction projects are often exceeded [13–15]. Depending on the data source, the overrun values vary. According to [4,5], cost overruns occur in as many as 9 out of 10 construction projects, and the value of the excess can be as high as 183%. For example, in the Netherlands the average cost overrun was 16.5% [16], in Portugal 24% [17], and in Qatar 54% [18,19]. In the USA, on the other hand, Hoffman's research [20] showed that 72% of the analysed buildings were not completed in accordance with the assumed goals. Similar results were obtained in Australia, India, China, Slovenia, Croatia and Poland, where a significant proportion of projects exceeded both time and budget [21–28].

In the literature on the subject, the relationship between the time of a construction project and the cost of implementation is indicated [11]. The first research in this field was carried out by Bromilow [29] in Australia, developing the "time-cost" (BTC) model. Bromilov developed a regression model to predict the duration of a construction project based on the estimated final cost. Later studies confirmed the usefulness of this method, but indicated that these models must be adapted to the specific economic conditions of each project [30–32]. Analyses show that more complex models that take into account additional variables can lead to more accurate results, but at the same time complicate their practical application [33,34]. For this reason, simpler models can be more realistic and practical [10].

Other studies [21,30,32,36] have shown that the time needed for implementation is strongly correlated with the construction volume measured by cost projection. It has also been shown that the causes of delays are in most cases the causes of cost overruns and vice versa. Some researchers even treat delay and cost overruns as the same thing [8,12].

Among the publications dealing with the subject of interdependence, there are also articles that question the existence of full correlation between cost overruns and deadline exceeds. The authors [2] at the outset pose the question of the size of cost deviations depending on the length of construction projects. Two types of projects were analysed: road and cubature investments. The results suggest that longer investment tasks do not necessarily have a greater cost variance.

All researchers, however, unanimously confirmed the need to conduct further research based on empirical research material, which allows for a real mapping of the course of construction projects. This confirmed the author's belief in the correctness of the chosen course of action, especially in the face of the accumulated research sample.

3. Method and Research

3.1. Earned Value Method (EVM)

The EVM Earned Value Method is now widely used and recommended for monitoring the progress of projects in many industries, and its roots date back to the 1980s. As a project management system, EVM is recommended by well-known methodologies such as PMBoK Guide (*Project Management Body of Knowledge Guide*) and IPMA (*International Project Management Association).* It is based on measuring the actual progress of the project, and then on the control of the investment task by cyclically comparing the scope of work with their planned time of execution and the planned cost of implementation.

The aim of the EVM method is to link the material progress of the work with the costs incurred and the planned budget of the project. This method is based on three key parameters, which are determined on the basis of data obtained during the periodic inspection of investments:

- BCWS (*Budgeted Cost of Work Scheduled*): also known as Planned Value (PV). Tis the value of the budget assigned to the work that should be completed by a specific point in time. This is the cumulative value, which is the sum of all planned costs for tasks that you want to complete up to a given point in the schedule. BCWS serves as a benchmark for comparison. actual progress of work with the plan;
- BCWP (*Budgeted Cost of Work Performed*): also known as Earned Value (EV). Represents the cumulative cost value, assigned to the actual work performed up to a specific point in time. The BCWP is a measure of physical advancement, i.e. the actual cost of an undertaking in the context of the planned budget;
- ACWP (*Actual Cost of Work Performed*): Actual Cost of Work Performed, is the actual cost incurred to perform the work up to a certain point in time. The ACWP reflects the actual costs incurred by the venture, which may include the cost of materials, labour, equipment rental, etc.

3.2. Research Sample

The data included in this research sample were collected and processed by the Research Team in the years 2006 – 2025. They constitute an extensive knowledge base on the course of 41 different construction projects, which can be classified into 5 typological groups in accordance with the division proposed in the Polish Classification of Construction Objects. The breakdown into individual typological groups and the number of investments included in them is presented in Table 1.

Table 1. Division of construction projects included in the research sample into typological groups with the number of measurements made.

Category	Sector of BIS projects	Number of projects	Number of measurements
M	Residential Buildings	14	218
O	Office Buildings	4	69
H	Hotel Buildings	9	110
G	Commercial Centres	8	113
L	Logistic Centres	6	37
A-H	**Totals**	**41**	**547**

The entire research sample includes 41 construction projects, classified into five groups, which are a reflection of selected typological groups in Poland.

 doi:10.20944/preprints202604.0954.v1

The first typological group (group M) included residential and multi-family buildings. The total number of projects in this group was 14. The average cost of implementation of projects in this group amounted to PLN 17,684,301.93, and the average implementation time was about 18 months. The total cost of all projects amounted to PLN 247,580,227. The total time of their implementation took 254 months.

The second group (group O) includes office buildings. The average cost of implementation of projects in this group amounted to PLN 41,518,299.71, and the average implementation time was about 30 months. The total cost of all projects amounted to PLN 166,073,198.83. The total time of their implementation was 121 months.

The third research group included hotel buildings (group H). A total of 9 projects were gathered in it. The average cost of their implementation was PLN 33,283,067.24, and the average implementation time was about 19 months. The total cost of all projects was 299,547,605.18. The total time of implementation of all hotel projects was 178 months.

Commercial centres (group G) were the subject of analyses carried out as part of the fourth separate group of projects. The total number of projects collected in this typological group was 8. The average cost of implementation of projects in this group amounted to PLN 65,965,340.49, and the average implementation time was about 15 months. The total cost of all projects amounted to PLN 527,722,723. The total time of their implementation was 121 months.

The last research group included logistics centres (group L). In total, it included 6 projects. The average cost of their implementation was PLN 22,232,458, and the average implementation time was about 9 months. The total cost of all projects was 133,394,749. The total time of implementation of all hotel projects was 55 months.

The total cost of the research sample, falling on the years 2006 – 2025, amounted to PLN 1,374,318,504.34. The total implementation time of all projects was 729 months.

It is worth noting that offices and hotels buildings (groups O and H) as well as the commercial centres (group G) have been carried out within sustainable requirements and all fulfilled either platinum or gold LEED certification. The logistic centres (group L) have been executed in line with BREEAM certification. The others analysed projects have been designed and constructed with allowance for key aspects of Sustainability.

Transformations in the research sample according to the EVM method enabled a full analysis of the course of cost and time variability of sustainable construction projects.

4. Results

In the first place, the S curve curves characteristic of each construction project are presented. They were developed on the basis of planned data resulting from the schedule (BCWS curves) and on the basis of the results obtained from the observation of the actual course of projects (AWCP curves). Since each investment is carried out in an individual way, depending on many factors, the boundaries of the S-curves are presented, which determine the cost and time range of each group of projects. This made it possible to assess the differentiation of the course of individual investments at individual stages within a given group. The last element of the observation was the assessment of the size of deviations from the average value, which made it possible to determine how much both the planned and generated investment costs may differ from the comparison of the entire group.

4.1. S-Curve Course

The S curve is a graph of the accumulated costs of the project during its implementation. Each subsequent value that makes up the chart is the sum of the value obtained in the previous period and the costs incurred in the current period. It is a tool used in some methods of investment management, including the EVM method used in this paper. Due to the differences in the costs and duration of the analysed investments, in order to unify and increase the transparency of the presented charts, data normalization was carried out. As a result, both the cost of the investment and its duration were reduced to the indicator values of "0" as the beginning and "1" as their end.

 doi:10.20944/preprints202604.0954.v1

Each investment is presented on a chart in an individual colour and marked with a code (e.g. M.4), in which the letter indicates belonging to a specific group of facilities, and the number refers to a specific project.

4.1.1. S-curves of the Cumulative Planned Cost

Planned cost values (BCWS) were obtained from the schedules of projects that were created at the planning stage. After dividing the research sample into groups of projects with the same profile, a summary graph of S-curves was prepared for all investments from the group of residential buildings (M) - Figure 1.

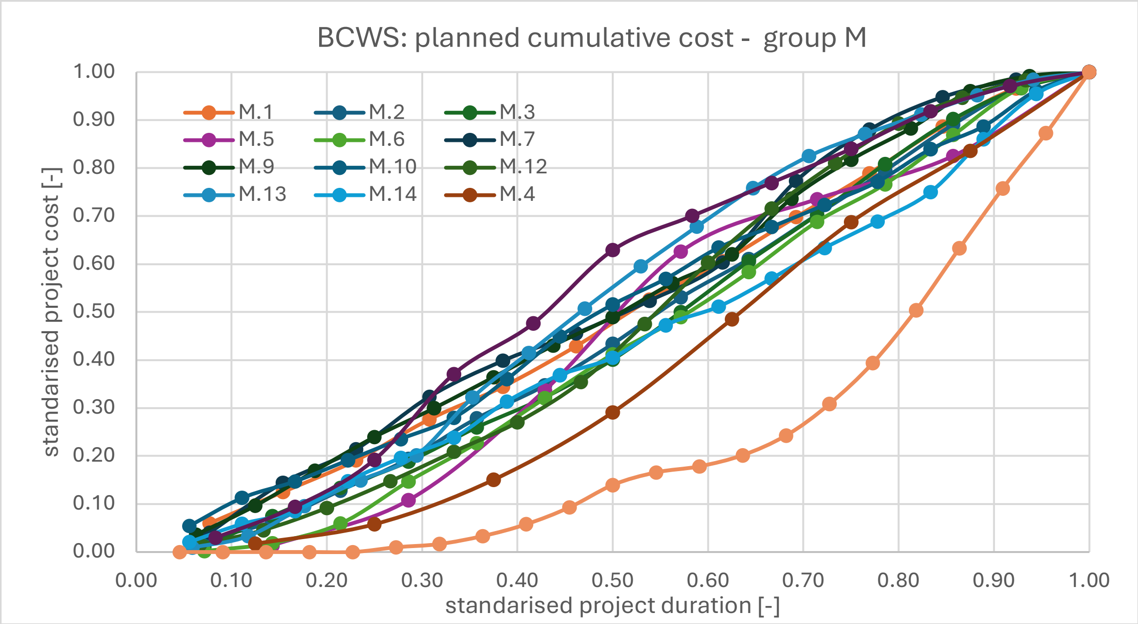

Figure 1. The planned S-curves for a group of residential buildings (M).

A narrow range of values was observed at almost every stage of implementation. The visible discrepancies between individual projects result from obvious differences, both technical and organizational, between them.

Another group of projects for which mileage charts have been developed are office buildings (O) (Figure 2.)

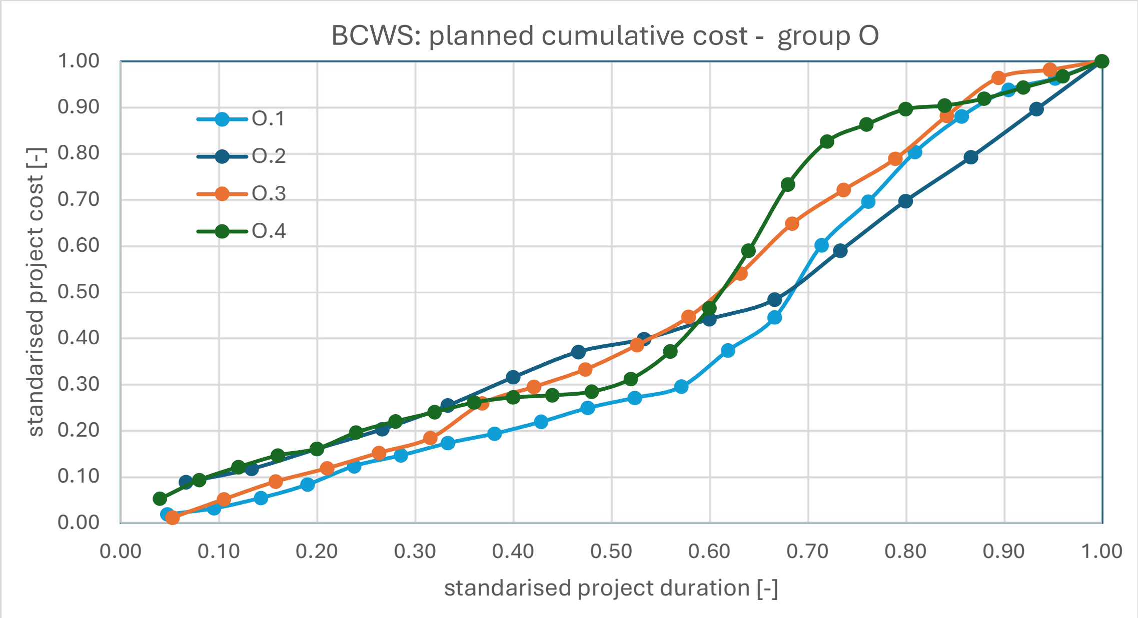

Figure 2. The planned S-curves for the office building group (O).

Up to about half of the course of all investments in this group, a large concentration of the obtained values is observed. This is the result of works of a similar nature carried out during this period. On the other hand, for about half of the time, a dispersion of values has been observed, which decreases as the planned completion of works approaches. The type of works (finishing works) performed in this time period, resulting from the varying degree of complexity and standard of the work performed, is also responsible for the dispersion.

In the group of hotel buildings (H), increasing differences between the values in individual investments were observed from the very beginning to about 2/3 of the progress of the implementation time (Figure 3).

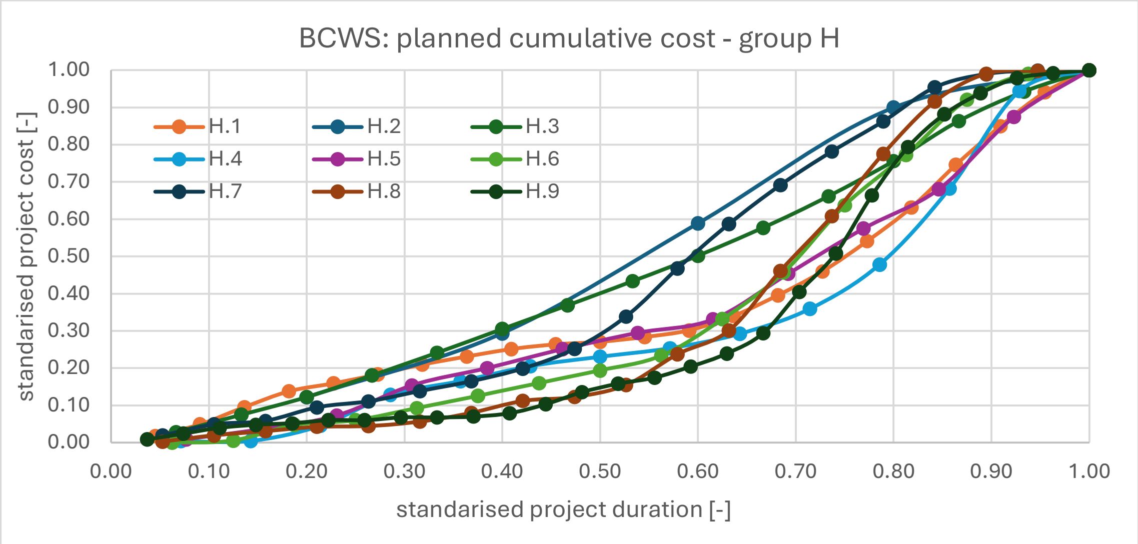

Figure 3. The planned S-curves for hotel building group (H).

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 14 April 2026 doi:10.20944/preprints202604.0954.v1

In the last 30% of the planned cost run, the focus of the BCWS increases up to 1. The relatively wide range of the cost of projects at individual stages of implementation results from the large variation between individual investments, which also results in different dynamics of their course.

Another analysed group is commercial centres (G) (Figure 4).

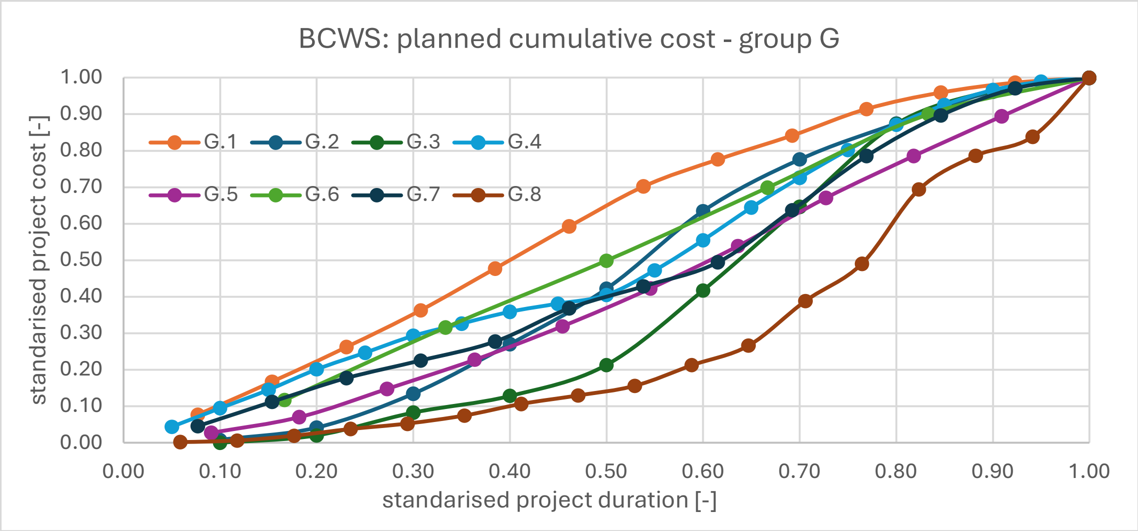

Figure 4. The planned S-curves for commercial centre group (G).

The course of the S-curves for this group of objects also shows discrepancies in the values obtained in individual projects, which increase to about 2/3 of the progress of the works. A gradual densification of the values is then observed until the completion of the projects. As in the case of hotel buildings (H), s centres (G) are characterized by a wide variety of works, which translates into varied dynamics of the course of these investments.

The last analysed group of construction projects are logistics centres (L). The course of cumulative planned costs of the BCWS is presented in Figure 5.

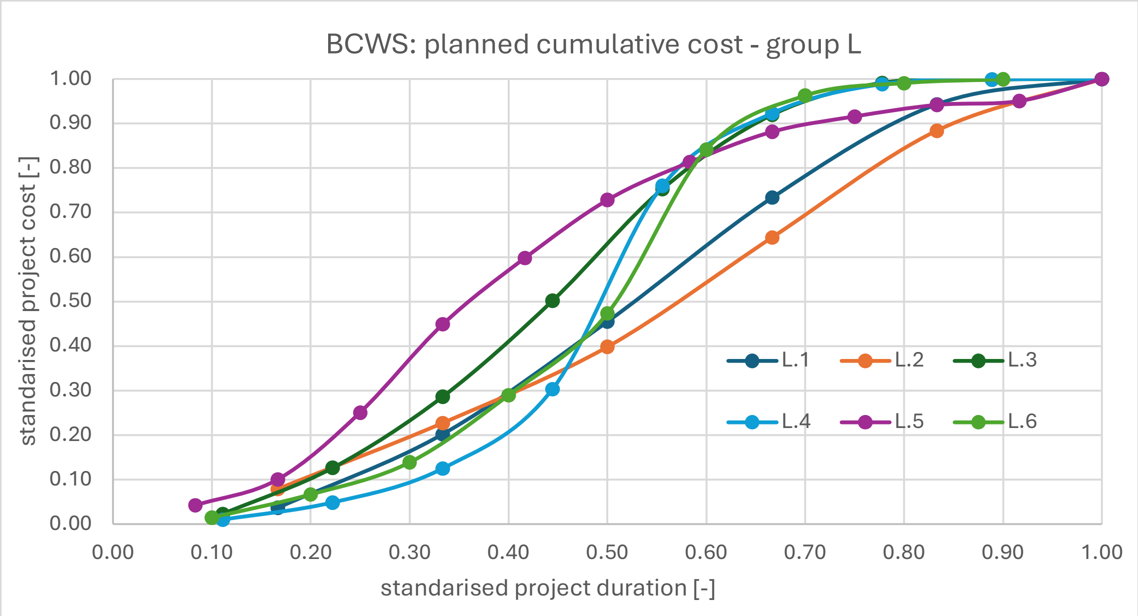

Figure 5. The planned S-curves for a group of logistics centres group (L).

It is characterized by a large variation in value in the range of 0.25 – 0.75 of the course of the investment. In the case of two investments, a dynamic increase is observed in about half of its progress.

4.1.2. S-curves of the Cumulative Actual Cost

The values of the actual cost incurred (ACWP) were obtained as a result of observing the current course of the investment. On the vertical axis, the graphs presented below show the relationship between the actual cost and the planned cost. The horizontal axis shows the original schedule on a standardized scale. The data is presented in a graph in a cumulative form. The way the data are presented clearly shows the differences between the planned and actual course of the research sample construction projects.

The actual cost value (ACWP) for a group of residential buildings (M) is shown in Figure 6.

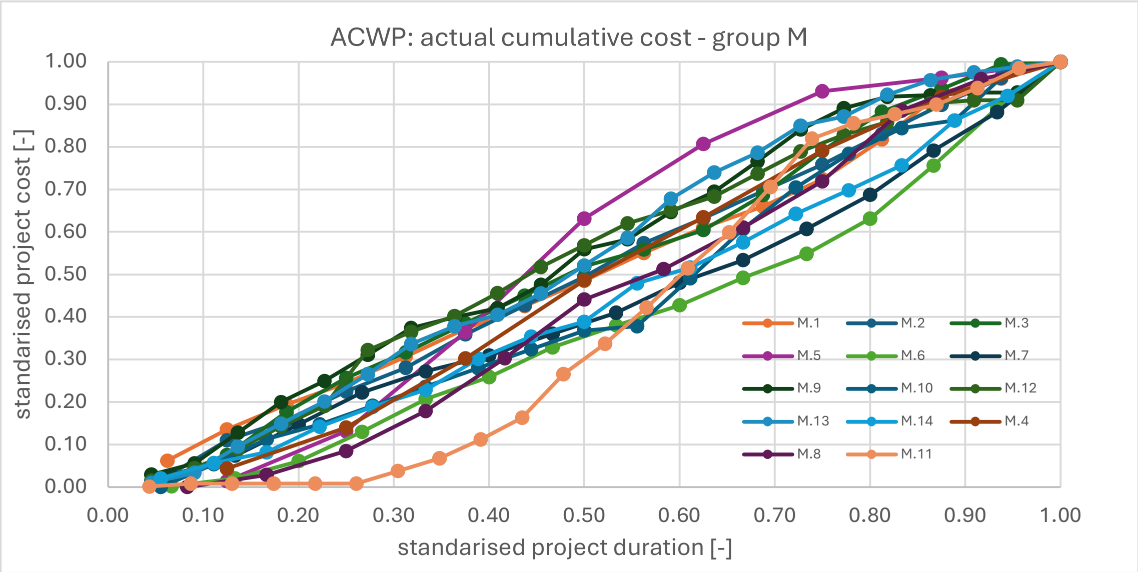

Figure 6. The actual S-curves for residential buildings group (M).

The presented graph shows the actual course of most projects that is close to linear. After about 70% advancement, there is a visible trend of dispersion of the value of the investment time. The deadline for most projects is also exceeded. Less frequent is the overrun of the actual cost.

In the area of office buildings (O), for which the actual cost of ACWP is presented in Figure 7, the linear nature of the value and very similar dynamics of the course to about 50% of the investment progress are observed. The relatively small angle of inclination of the chart in this range indicates a low level of financial outlays. The parallelism of the charts in the initial range indicates a similar structure of project management and a similar organizational level of construction. In subsequent time intervals, the width of the range of observed values increases, and the course of work is carried out with different intensity.

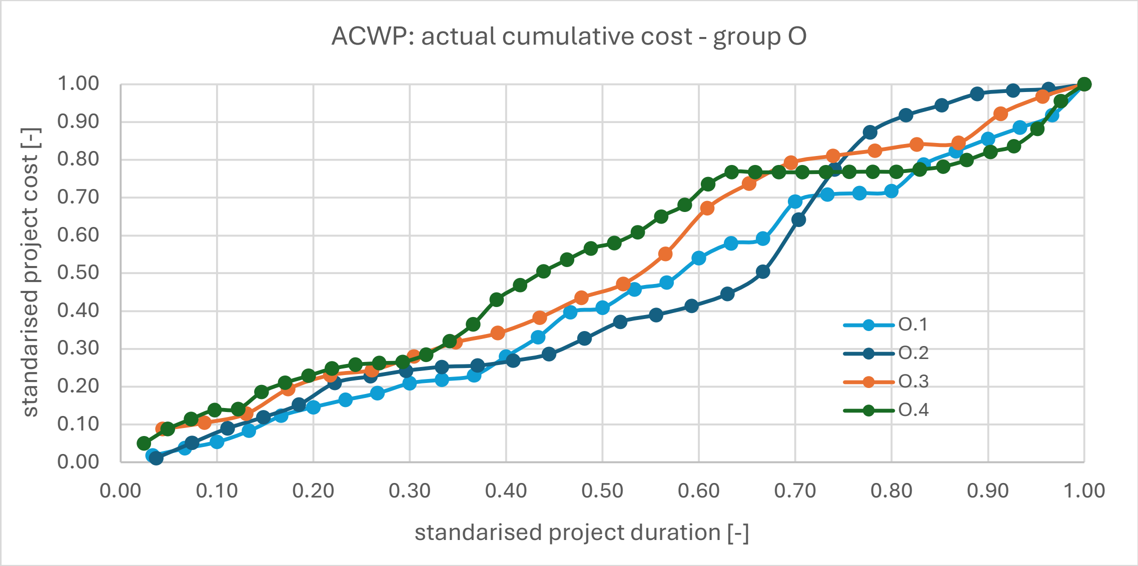

Figure 7. The actual S-curves for an office building group (O).

In the case of each investment, the deadline was exceeded, and in half of them the cost was also exceeded.

The course of the actual cost of projects (ACWP) for the group of hotel buildings (H) is shown in Figure 8.

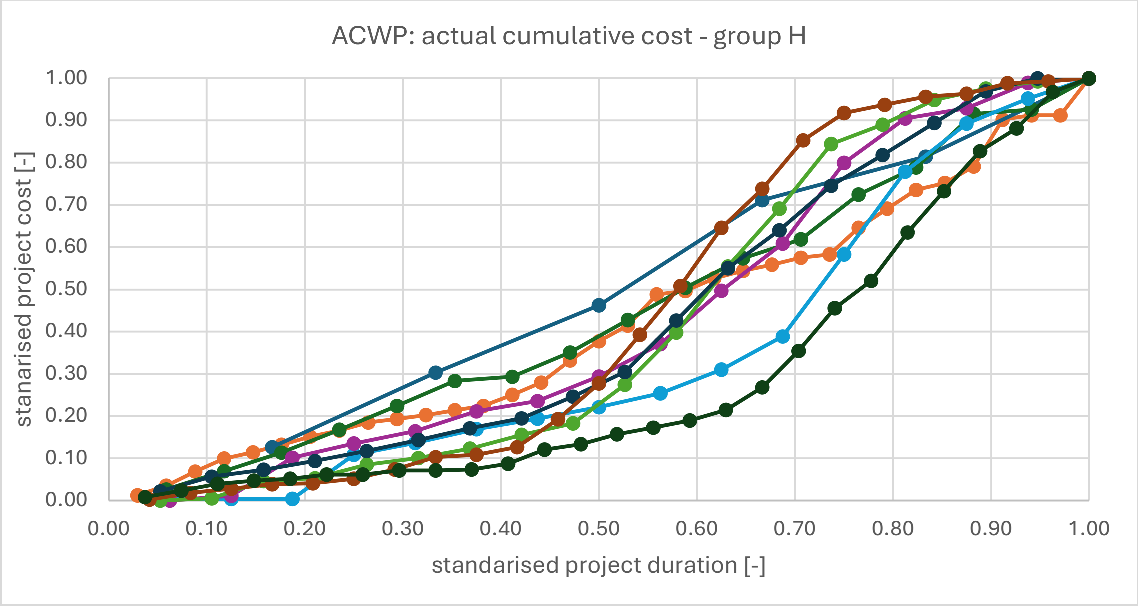

Figure 8. The actual S-curves for hotel building group (H).

In this group of facilities, the course of projects is characterized by an almost linear increase in cost to about 60% of advancement. The slight slope of the charts indicates a steady, slow progress of works in this initial range. In the remaining time frame, an increase in investment dynamics is observed, while maintaining the previously observed concentration of values, indicating a similar organizational level and a similar structure of investment management. In all the audited projects, the planned completion date was exceeded, and only in one case the planned cost was maintained.

In the group of commercial centres (G), for which the actual cost of the investment is shown in Figure 9, an almost linear nature of the cost-time relationship is observed.

 doi:10.20944/preprints202604.0954.v1

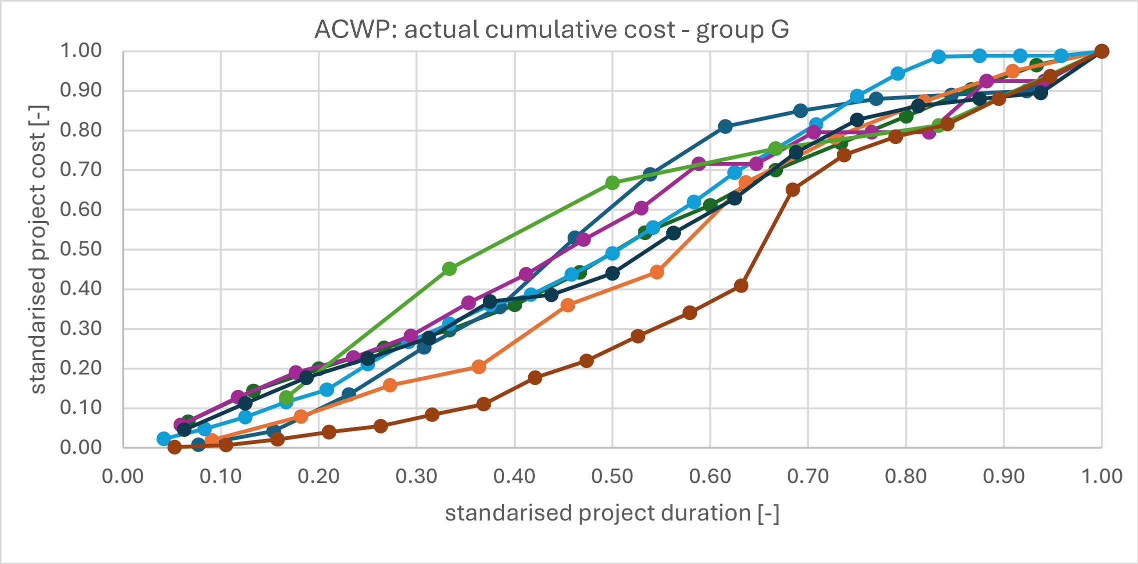

Figure 9. The actual S-curves for commercial centres group (G).

The increasing range of values in individual time periods testifies to the diverse organizational level resulting from the specificity of each project. In all observed investments, the deadline was exceeded, and only in two cases the cost was also exceeded.

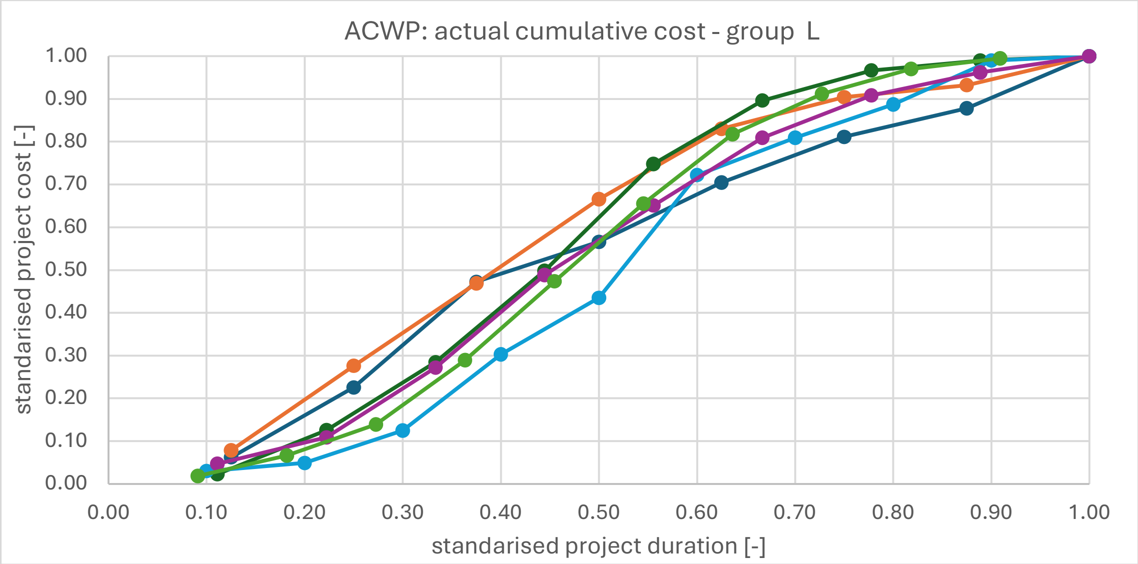

Figure 10. The actual S-curves for the logistic centre group (L).

The last group of projects for which the actual cost is presented in Figure 10 are logistics centres (L). Almost from the very beginning, a high increase in costs has been observed in all projects, which proves the high dynamics of this group of projects. The growing discrepancy between the values, visible from about 20% of the advancement, indicates a large variation in terms of management and organization of the observed investments. Also in this group of projects, over-schedule was observed in most cases. Only one investment slightly exceeded the planned cost.

4.1.3. Conclusions from the observation of the course of the S-curves

 doi:10.20944/preprints202604.0954.v1

On the basis of the observations carried out in individual groups of investments, several important observations were formulated:

- the curves determined for the group of residential buildings (M) are characterized by striving for linearity both in the planned (BCWS charts) and in the actual (ACWP charts) course of implementation;
- repeatedly breaking curves on graphs developed for office buildings (O) and their slight slope relative to time indicate uneven progress of work and its low dynamics;
- the group of hotel buildings (H) is characterized by high non-linearity of the curves, which proves the diverse dynamics of projects in subsequent time periods;
- the curves developed for the group of commercial centres (G) are characterized by a great variety that can be seen almost from the very beginning. This is related to a great diversity both in terms of construction and organization. Graphs are observed both with a small initial increment and inclined at a greater angle, which testifies to the varied dynamics of the course of projects;
- the high diversity of facilities from the group of commercial centres (G) is also evidenced by the diversity of the observed values. Some projects are characterized by a course similar to a linear one, while the course of others is more complex;
- the variable shape of the curves in the group of logistics centres (L) indicates a high dynamics of projects. A fairly wide range of values in individual time periods may also indicate both technical and organizational diversity;
- a much higher number of projects in which the deadline was exceeded was observed in relation to the number of projects in which the planned cost was exceeded

4.2. Area of S-Curves

The S-curve courses presented in section 4.1, developed for the research sample, allowed to observe specific trends within each analysed group of projects. On this basis, for each studied group, ranges of the S-curve field were developed, determining the areas of occurrence of the value of the actual cost of the project (ACWP). First, a trend line was developed for all values occurring in a given group, the function of which is described by a polynomial of degree 3. Then, based on the extreme points (both top and bottom), a boundary was drawn to close the area of occurrence of the data. For the curves forming the envelope, subsequent trend lines are determined, described by means of 3-degree polynomials. The closed area between these curves determines the range of values that make up the S curves based on the actual cost values.

4.2.1. S-Curves Area in Individual Groups of Construction Projects

The range of the S-curve field developed on the basis of the actual cost of the project (ACWP) values for the group of residential buildings (M) is shown in Figure 11.

 doi:10.20944/preprints202604.0954.v1

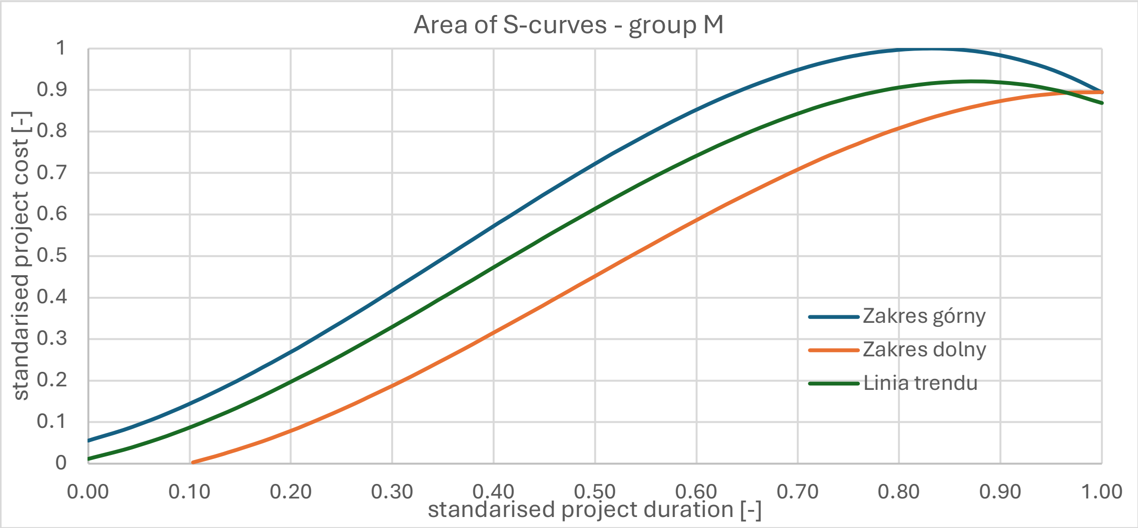

Figure 11. The range of S-curves for residential buildings group (M).

The middle curve S indicates the trend of the values in this group and allows you to estimate the magnitude of possible deviations in a given period of time. The curve field is characterized by a fairly large angle of inclination, indicating high dynamics of projects for most of their course, slowing down above about 75% of the progress of works.

The next group of curves shown in Figure 12 determines the area of the value field for projects from the group of office buildings (O).

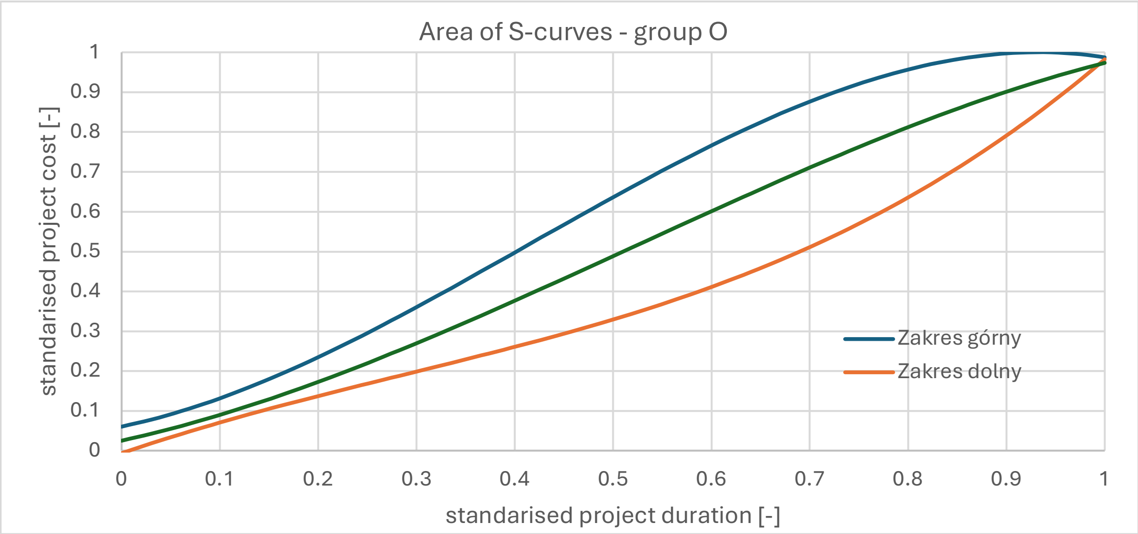

Figure 12. The range of S-curves for office building group (O).

The S-curve field for this group of projects is characterized by moderate dynamics of the course, as evidenced by a milder angle of the trend line than in the case of the previous group.

The S curve range developed for hotel buildings (H) shown in Figure 13 shows variable waveform dynamics with a maximum width of the value range of about 0.25.

 doi:10.20944/preprints202604.0954.v1

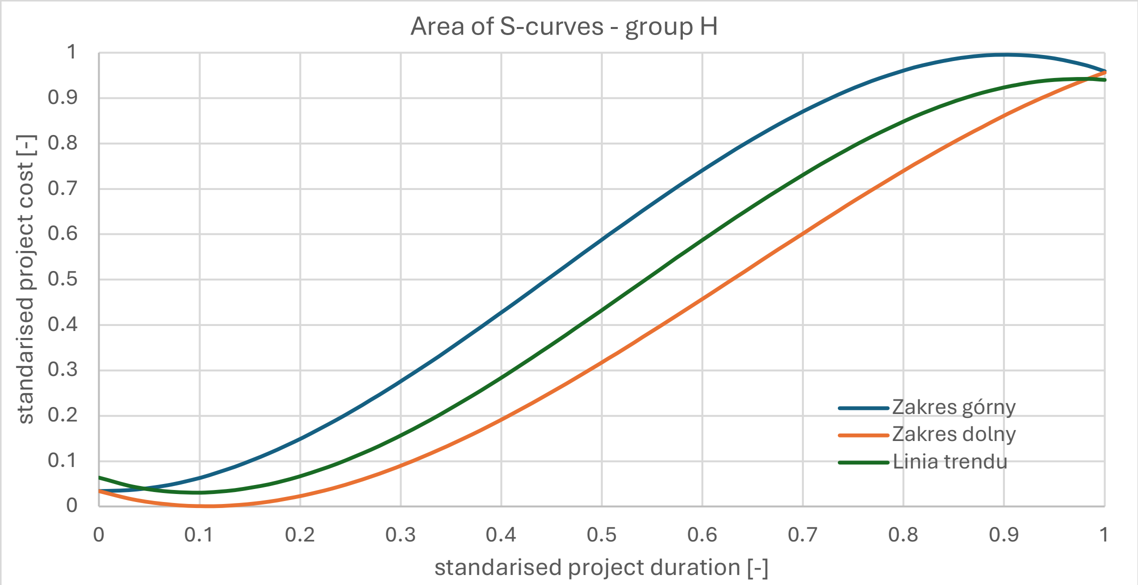

Figure 13. The range of S curves for hotel buildings group (H).

A group of facilities that stands out from the rest are commercial centres (G). Observing the ranges of S-curves shown in Figure 14, it should be noted that it expands significantly after exceeding about 1.5 times of the schedule.

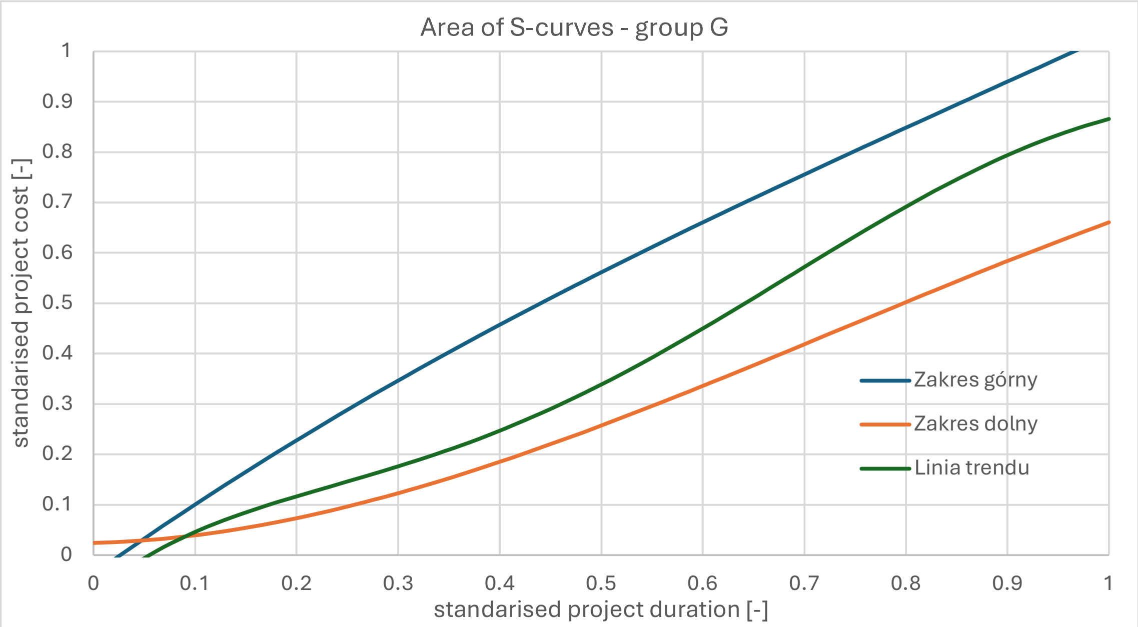

Figure 14. S-curve range for commercial centre group (G).

This means that after a significant exceeding of the planned completion date of the project, the approximate determination of the value may be significantly difficult.

In the last analysed group of facilities – logistics centres (L) – the most dynamic course of investments is observed (Figure 15).

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 14 April 2026 doi:10.20944/preprints202604.0954.v1

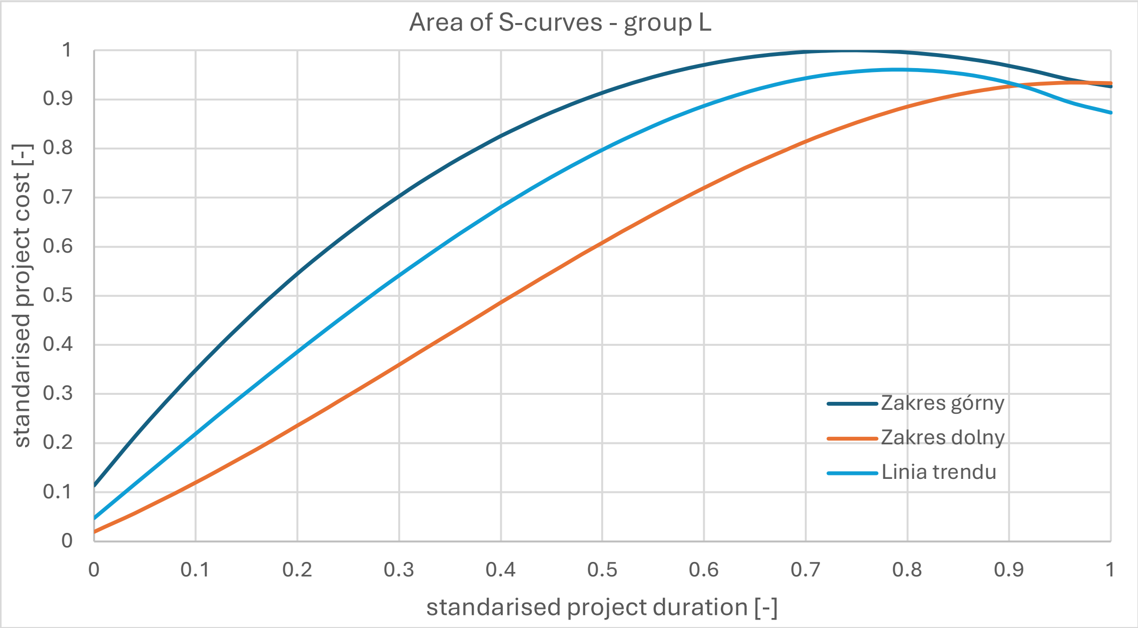

Figure 15. S-curve range for logistics centres group (L).

4.2.2. Conclusions from the analysis of S-curves field ranges

As a result of the observation of the range and shape of the area of the S-curves carried out in individual groups of objects, the following observations were formulated:

- the varied shape of the ranges of S-curve fields developed for individual groups of projects indicates the legitimacy of conducting analyses taking into account this division;
- the wide range of values in the group of commercial centres (G) results from their great diversity, both in terms of size, technology and multifunctionality, which has a significant impact on the dynamics of this type of undertakings;
- the group of office buildings (O), after exceeding about 50% of advancement, is also distinguished by an increase in the range of values, which is the result of a different standard of finishing and frequent introduction of other additional functions;
- the trend lines of the S-curves shown on the charts may indicate the likely course of the accumulated accrual cost, and the differences resulting from the comparison with the limiting curves indicate possible deviations;
- a comparison of the data obtained during the inspection of a construction project with the appropriate range of the S-curve area may be an indication to determine the correctness of its course – values exceeding the designated range of the field may indicate too large deviations and require the introduction of corrective actions.

5. Discussion and Summary

The key objective of the observations and analyses carried out in this chapter is to determine the relationship and course of the two most important parameters of the investment process, which are cost and time. For this purpose, the method of determining S-curves was used in the first place. Although it is simple and based only on a material and financial schedule, which is why it is not always accurate, it can present the course of cost and time values of already completed projects in a very accessible and legible way.

On the basis of observations of the course of the S-curves, the correctness of dividing the research sample into groups of objects with different functions was confirmed. Clear differences in the observed values and varied trends in their course were observed. It is also worth noting that in each

 doi:10.20944/preprints202604.0954.v1

group there are projects in which the actual cost or deadline for completion was exceeded in relation to the planned values during implementation.

The boundaries of the S-curves presented in the graphs made it possible to specify the value fields of the analysed parameters in the next stage. Assuming that the current cost values at a given date are within the curve field, it can be concluded that further values will also be maintained in this area. Obtaining values exceeding the curve field should be a signal of irregularities in the course of the project and an impulse to introduce remedial measures aimed at restoring the rational course of work.

The results of the analyses allowed for the implementation of the main objective of the research, which was to determine the relationship between the cost of the investment and the time of its implementation in sustainable and diverse investment tasks. The effect of achieving this goal is to confirm the correctness of the main thesis of the research: **cost and time of implementation are not completely interdependent parameters and show great variability during the implementation of typologically diverse, although uniformly balanced construction projects.**

Finally – as regard sustainability – there is no correlation between sustainable de-sign with execution and cost deviations of construction projects. In a nutshell, an assessor of green certification appraises management, health and wellbeing, energy, transport, water, materials, waste, land use and ecology, pollution and innovation. All of these categories need discipline and accurate cost control provided by a professional construction project management (CPM). Such detailed analysis of the course of cost variability of sustainable diverse enterprises leads to the main conclusion: design and construction of sustainable projects in accordance to LEED or BREEAM certification does not guarantee execution projects in line with their Capital Cost Estimation (CAPEX), no matter what sector the project belongs to.

The literature on such a research problem, e.g. [37,38], does not indicate unambiguous tools for determining the interdependence of related variables or their characteristics. A natural study of the occurrence of the relationship between variables and the strength of their connection are statistical correlation coefficients [39], which do not fully answer the question of whether there is a correlation between the cost and time of construction projects, especially since it may be variable during the implementation of the project.

The authors write about the strong correlation between delay and cost overrun [11]. In the articles [8,12], researchers see the reason for delays in undertakings as exceeding their cost and vice versa. Thus, they treat over-deadline and cost overruns as strongly linked. The article [2] confirms the correctness of the search for an answer to the question whether construction projects with a longer implementation period are always characterized by a greater cost deviation than short investment tasks, in which the authors prove that extending the duration of projects does not always result in a larger cost deviation. It is one of the few publications in which the close correlation between the cost and time of construction investments is clearly questioned.

Due to the complexity and multi-threaded nature of the issues discussed in this article and the need to limit them due to the size of the research sample, it is advisable to conduct further research on the impact of cost and deadline exceedances on each other – not only their interdependence, but also the size and significance of these basic features of the investment process.

It is also planned to take into account the causality of the resulting cost and time deviations, which will allow to obtain a more reliable projection of the course of construction projects. Continuing the study of cost and time parameters for the implementation of new investment tasks is a long-term and complex cognitive challenge, but necessary to obtain a larger quantitative, and thus more representative research sample for full statistical inference in relation to selected typological groups and extrapolation of results to the entire field of construction.

 doi:10.20944/preprints202604.0954.v1

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Some or data, models, or code that support the findings of the study are available from the corresponding author upon reasonable request, namely: data on the analysed construction projects in the field of: 1) work and expenditure schedule, 2) monthly financial statements containing, among others, the percentage advancement and the value of works completed in a given settlement period, the increasing value of works completed since the beginning of works, and also the value of works that remain to be carried out, 3) actual cost and time of completing the investment. Some or data, models, or code generated or used during the study are proprietary or confidential in nature and may only be provided with restrictions, namely: detailed data on the analysed construction projects in the field of: 1) characteristic technical parameters of the objects (e.g. build-up area, total area, usable area, etc.), allowing its identification, 2) investments location, 3) detailed data about the investors (name, headquarters, etc.), 4) data about the banks financing the projects, 5) trade name of the investments project.

Conflicts of Interest: The author declares no conflict of interest.

References

1. Kerzner, H. (2003). Project management: A Systems Approach to Planning, Scheduling, and Controlling eighth edition. *John Wiley & Sons, Inc.*, *34*(8).
2. Belay, A. M., & Torp, O. (2017). Do Longer Projects Have Larger Cost Deviation Than Shorter Construction Projects? *Procedia Engineering*, *196*. https://doi.org/10.1016/j.proeng.2017.07.198
3. Kaka, A., & Price, A. D. F. (1991). Relationship between value and duration of onstruction projects. *Construction Management and Economics*, *9*(4). https://doi.org/10.1080/01446199100000030
4. Flyvbjerg, B., Holm, M. S., & Buhl, S. (2002). Underestimating costs in public works projects: Error or lie? *Journal of the American Planning Association*, *68*(3). https://doi.org/10.1080/01944360208976273
5. Flyvbjerg, B., Skamris Holm, M. K., & Buhl, Sø. L. (2004). What causes cost overrun in transport onstructione projects? *Transport Reviews*, *24*(1). https://doi.org/10.1080/0144164032000080494a
6. Le-Hoai, L., & Lee, Y. D. (2009). Time-cost relationships of building construction project in Korea. *Facilities*, *27*(13). https://doi.org/10.1108/02632770910996379
7. Burtonshaw-Gunn, S. A. (2017). Risk and financial management in construction. W *Risk and Financial Management in Construction*. https://doi.org/10.4324/9781315244112
8. Le-Hoai, L., Lee, Y. D., & Lee, J. Y. (2008). Delay and cost overruns in Vietnam large construction projects: A comparison with other selected countries. *KSCE Journal of Civil Engineering*, *12*(6). https://doi.org/10.1007/s12205-008-0367-7
9. Car-Pušić, D., & Radujković, M. (2009). Construction time-cost model in Croatia. *International Journal for Engineering Modelling*, *22*(1–4), 63–70.
10. Žujo, V., Car-Pušić, D., Žileska-Pančovska, V., & Ćećez, M. (2017). Time and cost interdependence in water supply system construction projects. *Technological and Economic Development of Economy*, *23*(6). https://doi.org/10.3846/20294913.2015.1071292
11. Anysz, H., & Buczkowski, B. (2019a). The association analysis for risk evaluation of significant delay occurrence in the completion date of construction project. W International Journal of Environmental Science and Technology (T. 16, Numer 9). https://doi.org/10.1007/s13762-018-1892-7
12. Seddeeq, A. Bin, Assaf, S., Abdallah, A., & Hassanain, M. A. (2019). Time and Cost Overrun in the Saudi Arabian Oil and Gas Construction Industry. *Buildings 2019, Vol. 9, Page 41*, *9*(2), 41. https://doi.org/10.3390/BUILDINGS9020041
13. Makesh, S., & Mathivanan, M. (2019). Analysis on causes of delay in building construction. *International Journal of Innovative Technology and Exploring Engineering*, *8*(7).

14. Rachid, Z., Toufik, B., & Mohammed, B. (2019). Causes of schedule delays in construction projects in Algeria. *International Journal of Construction Management*, *19*(5). https://doi.org/10.1080/15623599.2018.1435234
15. Kowalski, J., Połoński, M., Lendo-Siwicka, M., Trach, R., & Wrzesiński, G. (2021). Method of assessing the risk of implementing railway investments in terms of the cost of their implementation. *Sustainability (Switzerland)*, *13*(23). https://doi.org/10.3390/su132313085
16. Cantarelli, C. C., Molin, E. J. E., Van Wee, B., & Flyvbjerg, B. (2012). Characteristics of cost overruns for Dutch transport constructione projects and the importance of the decision to build and project phases. *Transport Policy*, *22*. https://doi.org/10.1016/j.tranpol.2012.04.001
17. 17.Miranda Sarmento, J., & Renneboog, L. (2017). Cost Overruns in Public Sector Investment Projects. *Public Works Management and Policy*, *22*(2). https://doi.org/10.1177/1087724X16668357
18. Senouci, A. B., & Mubarak, S. A. (2016a). Multiobjective optimization model for scheduling of construction projects under extreme weather. *Journal of Civil Engineering and Management*, *22*(3), 373–381. https://doi.org/10.3846/13923730.2014.897968
19. Senouci, A., Ismail, A., & Eldin, N. (2016). Time Delay and Cost Overrun in Qatari Public Construction Projects. *Procedia Engineering*, *164*. https://doi.org/10.1016/j.proeng.2016.11.632
20. Hoffman, G. J., Thal, A. E., Webb, T. S., & Weir, J. D. (2007). Estimating Performance Time for Construction Projects. *Journal of Management in Engineering*, *23*(4). https://doi.org/10.1061/(asce)0742-597x(2007)23:4(193)
21. Skitmore, M., & Thomas, N. (2001). Australian project time-cost analysis: Statistical analysis of intertemporal trends. *Construction Management and Economics*, *19*(5). https://doi.org/10.1080/01446193.2001.9709621
22. Kenny, C. (2010). Publishing Construction Contracts and Outcome Details. *World Bank Policy Research Working Paper Series*, *March*.
23. Sun, C., & Xu, J. (2011). Estimation of Time for Wenchuan Earthquake Reconstruction in China. *Journal of Construction Engineering and Management*, *137*(3). https://doi.org/10.1061/(asce)co.1943-7862.0000277
24. Konior, J., & Szóstak, M. (2020b). Methodology of planning the course of the cumulative cost curve in construction projects. *Sustainability (Switzerland)*, *12*(6). https://doi.org/10.3390/su12062347
25. Konior, J., & Szóstak, M. (2020c). The S-curve as a tool for planning and controlling of construction process-case study. *Applied Sciences (Switzerland)*, *10*(6). https://doi.org/10.3390/app10062071
26. Konior, J., & Szóstak, M. (2021a). Cumulative cost spent on construction projects of different sectors. *Civil Engineering and Architecture*, *9*(4). https://doi.org/10.13189/cea.2021.090404
27. Konior, J., & Szóstak, M. (2021b). Time and Cost Variance of Construction Projects Monitored by Bank Investment Supervision. W *Lecture Notes in Civil Engineering* (T. 122). https://doi.org/10.1007/978-3-030-63879-5_16
28. Konior, J., & Szóstak, M. (2023). Course of planned, actual and earned cost curves of diverse construction investments. *International Journal of Construction Management*, *23*(5). https://doi.org/10.1080/15623599.2021.1942769
29. Bromilow, F. J. (1969). Contract time performance expectations and the reality. *Building Forum*, *1*(3), 70–80.
30. Chan, A. P. C. (1999). Modelling construc durations in Hong Kong. *Construction Management and Economics*, *17*(2). https://doi.org/10.1080/014461999371682
31. Chan, A. P. C. (2001). Time-cost relationship of public sector projects in Malaysia. *International Journal of Project Management*, *19*(4). https://doi.org/10.1016/S0263-7863(99)00072-1
32. Chan, D. W. M., & Kumaraswamy, M. M. (1995). A study of the factors affecting onstruction durations in Hong Kong. *Construction Management and Economics*, *13*(4). https://doi.org/10.1080/01446199500000037
33. Nkado, R. N. (1992). Construction time information system for the building industry. *Construction Management and Economics*, *10*(6). https://doi.org/10.1080/01446199200000048
34. Love, P. E. D., Edwards, D. J., Irani, Z., & Walker, D. H. T. (2009). Project pathogens: The anatomy of omission errors in construction and resource engineering project. *IEEE Transactions on Engineering Management*, *56*(3), 425–435. https://doi.org/10.1109/TEM.2008.927774

 doi:10.20944/preprints202604.0954.v1

35. Love, P. E. D., Tse, R. Y. C., & Edwards, D. J. (2005). Time–Cost Relationships in Australian Building Construction Projects. *Journal of Construction Engineering and Management*, *131*(2). https://doi.org/10.1061/(asce)0733-9364(2005)131:2(187)
36. Walker, D. H. T. (1995). An investigation into construction time performance. *Construction Management and Economics*, *13*(3). https://doi.org/10.1080/01446199500000030
37. Zhao, T. (2023). Correlation and Causation in Construction Claims. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, *15*(3). https://doi.org/10.1061/JLADAH.LADR-979
38. Ngwenya, L., Aigbavboa, C., & Thwala, W. (2019). Critical success factors for improved organizational performance. *International Conference on Construction in the 21st Century*
39. Naji, K., Gunduz, M., & Salat, F. (2021). Assessment of preconstruction factors in sustainable project management performance. *Engineering, Construction and Architectural Management*, *28*(10), 3060–3077. https://doi.org/10.1108/ECAM-05-2020-0333